APPENDIX E

HUMAN HEALTH RISK ASSESSMENT

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Southern California Gas Company
Playa del Rey Gas Storage Facility

April 2004

Prepared for:

California Public Utilities Commission

Under contract to
Environmental Science Associates

Prepared by:

BROWN AND CALDWELL

400 Exchange, Suite 100
Irvine, California 92602

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EXECUTIVE SUMMARY

This report presents a human health risk assessment (risk assessment) for chemicals found in samples of environmental media (soil, soil vapor and groundwater) at 36 lots of land that are a part of Southern California Gas Company's (SCG) Playa del Rey Gas Storage facility. SCG has requested that the California Public Utilities Commission (CPUC) authorize the sale of these lots. The lots were historically used for oil production, and more recently in gas storage reservoir operations. This risk assessment is part of a series of investigations and reports by the Environmental Science Associate's team as a result of SCG's filing an application (A) No. 09-05-029 seeking CPUC authority under Public Utilities Code Section 851 to sell the 36 lots. The CPUC oversees the divestiture of utility properties to assure that they are suitable for transfer.

This risk assessment evaluates the potential human health risks associated with chemicals detected in the studies conducted by Brown and Caldwell in 2003. Human health risk assessment is a formal process that combines information on how people could come into contact with chemicals (exposure) with information on the health effects of the chemicals (toxicity) into estimates of the likelihood that an adverse health effect could occur. Risk assessment does not predict actual health effects but is a tool to determine whether mitigation measures are warranted if the CPUC approves the proposed sale.

In summary, the results for the 36 lots in Playa and Marina del Rey indicate that the total cancer risk for all types of exposure to a resident, assuming 30-year exposure to the maximum chemical concentration found in any sample at any lot, is 4×10^{-7} (four in 10 million risk level). This risk level is less than one half the lowest level of no-significant risk of 1×10^{-6} (one in a million risk level) set by California Environmental Protection Agency (Cal/EPA) and U.S. Environmental Protection Agency (U.S. EPA). Cal/EPA and U.S. EPA have established a range of acceptable cancer risks of 1×10^{-4} to 1×10^{-6} for Superfund Sites. This means that the acceptable target risk range for cancer risk levels is between an upper limit of 1 in 10,000 probability to a de minimis level of 1 in 1,000,000.

Based on the results for the Playa and Marina del Rey sites, an individual who is exposed for 30 years as a child and adult will have an increased probability of incidence of cancer of 0.0000004 over their baseline risk. An individual's baseline risk of contracting cancer over a lifetime in the United States is about 0.25. Therefore, this exposure will not increase their probability of risk significantly (0.2500004). Figure ES-1 shows the total cancer risk as well as the risk from individual exposure pathways. The total noncancer hazard index for all chemicals and all types of exposure is 0.6 which is well below the level of 1.0 considered safe for lifetime exposure by U.S. EPA and Cal/EPA for children.

Although these results indicate that conditions are safe for unrestricted use, mitigation measures are recommended for the Environmental Impact Report because the model that both the U.S. EPA and Cal/EPA use (the only model for vapor intrusion) is controversial and scientists are not in agreement that vapor migration is sufficiently understood to rely on model results. Mitigation measures for vapor intrusion could include institutional controls (such as deed restrictions) or engineered controls (such as vapor barriers) such as required by the Los Angeles City Building Code Section 91.106.4.1 and Division 71 of Article 1, Chapter IX of the Los Angeles Municipal Code. This code requires mitigations for methane and other gases be implemented when future construction occurs. These measures include the installation of vapor membrane barriers and vent piping as well as trench dams and electrical seal offs for each of these sites.

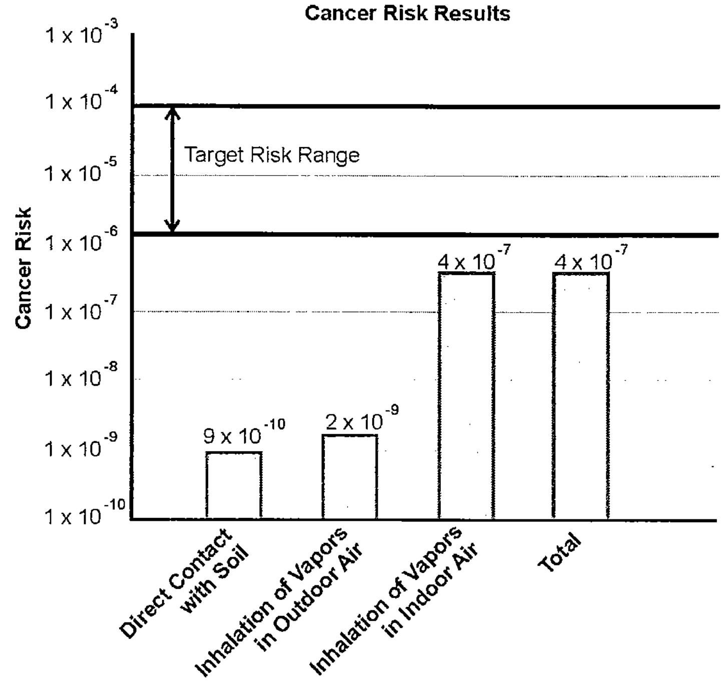

Figure ES-1. Comparison Site Risk to Target Risk Range

The following is a brief summary of the steps used in the risk assessment:

- **Data Evaluation** – presents the analytical data that will be used in the risk assessment. The sample locations were selected in an iterative fashion to assure that the samples were collected in areas most likely to be impacted and closest to any abandoned oil wells. The samples collected were analyzed for total petroleum hydrocarbon (TPH), volatile organic chemicals (benzene, toluene, ethylbenzene, and xylene) and semivolatile organic chemicals. The laboratory results for these chemicals include 86 soil samples (48 from depths 15 feet or less), 231 soil vapor samples and 21 groundwater samples.

  Methane and **hydrogen sulfide** are two gases that were sampled for in the investigations but not included in this human health risk assessment. Both of these gases are evaluated in separate reports. At this time, there is no evidence that hydrogen sulfide in outdoor air is elevated due to releases from the vapors at the property clusters. And therefore, hydrogen sulfide was not included in the risk assessment. Methane is not included in this risk assessment because the primary effects are as an asphyxiant (replaces oxygen) and explosive at high concentrations. A separate evaluation was conducted to evaluate the risks associated with high concentrations of methane. Methane was not included in this risk assessment for lifetime exposure because concentrations below the levels of concern as an asphyxiant or explosive are not known to have long term health effects.

- **Exposure Assessment** – calculates the amount of chemicals that people could potentially take in if they were exposed to chemicals (daily intake). In summary, the most likely ways that people could come into contact with chemicals (exposure pathways) include inhalation of chemical vapors that have migrated into indoor or outdoor air from soil, groundwater or underground storage units, ingestion of chemicals in soil, inhalation of chemicals on particles of soil and absorption of chemicals from soil on their skin.

  This risk assessment used the maximum concentration of chemicals detected in any sample on any lot to calculate the highest potential exposure. U.S. EPA and Cal/EPA protocols use a lower average concentration. In addition, the exposure assumptions used to calculate daily intake rates are designed to be higher than is reasonably likely to occur, so that if any exposure does occur, it is expected to generally be less than these estimates. These assumptions describe a hypothetical resident adult and child who are assumed to be in contact with the chemicals for 350 days a year for 30 years, 6 years as a child and 24 years as an adult at the maximum concentration.

- **Toxicity Assessment** – presents the toxicity factors that, combined with the daily intake from the exposure assessment, are used to calculate the risk. The health effects are grouped into potential carcinogenic effects and noncarcinogenic health effects, e.g., liver damage. Benzene is the only chemical identified that is considered to be a known human carcinogen. The other chemicals are only known to have noncarcinogenic health effects. Cancer risk and noncancer hazard are both evaluated in this risk assessment.

- **Risk Characterization** – combines the daily intake from the exposure assessment and toxicity factors to evaluate the potential for adverse health effects. The potential health risks are estimated for both carcinogenic and noncarcinogenic health effects. The results are presented in the opening portions of this summary.

- **Uncertainty Analysis** – identifies sources of uncertainty considered in the risk assessment analysis and discusses the level of confidence that can be placed in the findings. There is uncertainty in any risk assessment due to natural variability, e.g. people do not breathe at the same rate, and scientific assumptions, e.g. toxicity data is largely based on tests with animals. To compensate for this variability, every effort is made to represent worst case conditions. For example, sample locations were biased to areas of known or suspected impacts. The maximum concentration found in any sample was used to create a hypothetical worst-case location for exposure. In addition, U.S. EPA and Cal/EPA assumptions for how long exposure could occur or how toxic a chemical might be are designed represent reasonable maximum conditions. These efforts increase the level of confidence that the risk assessment findings are reliable.

  As noted earlier, this risk assessment recommends mitigation measures such as required by Los Angeles City Building Code Section 91.106.4.1 and Division 71 of Article 1, Chapter IX of the Los Angeles Municipal Code in light of the controversy surrounding modeling of vapor intrusion.

1.0 INTRODUCTION

This report presents a human health risk assessment for chemicals found in samples of environmental media (soil and soil vapor) at 36 lots of land that were once part of SCG's Playa del Rey Gas Storage facility. These undeveloped lots are located in residential neighborhoods of Playa del Rey (34 lots) and Marina del Rey (2 lots) within the City and County of Los Angeles. The lots were historically used for oil production, and more recently for gas storage reservoir operations.

On May 12, 1999, SCG submitted Property Divestiture 851 Application (Number 99-05-029) to the CPUC seeking approval of the sale of the lots by the CPUC. In 2003, CPUC hired Environmental Science Associates (ESA) and Brown and Caldwell to perform environmental impact reports and investigations of the lots, including the preparation of this risk assessment. The results of the environmental assessment studies are documented in a Report on the Results of Environmental Site Assessment Activities published under a separate cover (Brown and Caldwell 2004).

This risk assessment evaluates the potential human health risks associated with chemicals detected in the 2003 studies conducted by Brown and Caldwell. Human health risk assessment is a formal process that combines information on how people could come into contact with chemicals (exposure) with information on the health effects of the chemicals (toxicity) into estimates of the likelihood that an adverse health effect could occur. The risk assessment was prepared in accordance with Cal/EPA and U.S. EPA guidances' including, but not limited to, "Preliminary Endangerment Assessment Guidance" (Cal/EPA 1994), "Risk Assessment Guidance for Superfund (RAGS), Volume 1, Human Health Evaluation Manual," (U.S. EPA 1989), U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) (U.S. EPA 2002), as well as additional guidances' listed in the references. The risk assessment was prepared using the following six steps:

1. **Introduction** – provides a summary of how the risk assessment was prepared, a background on the proposed CPUC Divestiture Project, descriptions of the sites and the investigation process used to collect samples of environmental media.

2. **Data Evaluation** – includes an evaluation and summary of the analytical data, and discusses the chemicals that were identified in the environmental media.

3. **Exposure Assessment** – identifies activities that bring people into contact with chemicals and estimates the chemical concentrations to which people could be exposed.

4. **Toxicity Assessment** – discusses the toxicological properties and potential health effects of the chemicals of potential concern.

5. **Risk Characterization** – combines the exposure and toxicity information to evaluate the potential for adverse health effects. The potential health risks are estimated for both carcinogenic and noncarcinogenic health effects.

6. **Uncertainty** – identifies sources of uncertainty in the risk assessment and discusses the level of confidence that can be placed in the findings.

Figure 1-1 shows the relationship between the four key risk assessment steps.

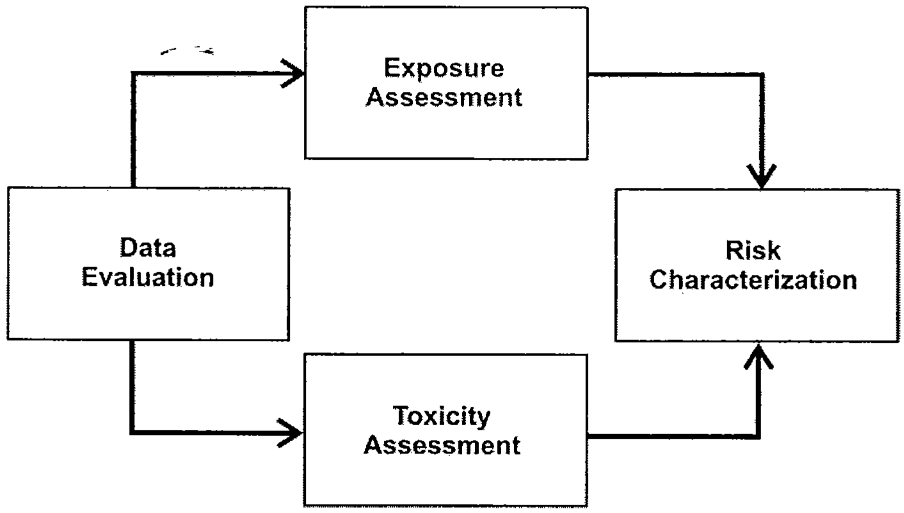

Figure 1-1. Risk Assessment Steps

In summary, the findings indicate that the potential for cancer risk or noncancer hazard health effects, if any exist, would be well below levels considered insignificant by state and federal agencies for all chemicals detected in any sample and at any location. However, to address one of the most important sources of uncertainty, this risk assessment recommends that mitigation measures such as required by Los Angeles City Building Code Section 91.106.4.1 and Division 71 of Article 1, Chapter IX of the Los Angeles Municipal Code for methane and other gases be implemented when future construction occurs at these sites. These measures include the installation of vapor membrane barriers and vent piping as well as trench dams and electrical seal offs.

1.1 Site History

The 36 lots are located approximately 1.5 miles north of Los Angeles International Airport in Playa del Rey and Marina del Rey, California. Figure 1.1.1 is a topographic map depicting the general location. Thirty four lots in Playa del Rey are grouped into 11 property clusters of adjacent lots. There is also one cluster containing 2 lots in Marina del Rey. Figure 1.1.2 shows the locations of the 11 property clusters in the Playa del Rey area. The two lots in the Marina del Rey cluster are shown on Figure 1.1.3.

The following is a summary of the general history of the oil and gas activities on the lots that was provided by SCG. The 11 oil and gas wells at the property clusters located in Playa del Rey were drilled in 1935-1936 to produce crude oil. Eight of the Playa del Rey oil wells were abandoned between 1936 and 1942. Oil well abandonment is regulated by the California Division of Oil, Gas and Geothermal Resources (DOGGR). Well abandonment involves measures that will prevent migration of fluids or gas to the surface including measures such as filling the casing of the well with cement at specific intervals and mud. There is also an inspection of cement plugs by the Division of Oil, Gas and Geothermal Resources after completion of the abandonment. The remaining 3 Playa del Rey wells were not abandoned in these early years and produced oil and gas during this period.

Six wells were re-drilled in 1955-1956 by SCG for use in their storage operations. The other two wells were re-abandoned in 1956 and 1958 to standards current at that time, and were never used in the SCG gas storage operations. The nine Playa del Rey wells used by SCG in their gas storage operations were primarily used as observation and fluid removal wells. When it was determined that they were not vital to the storage reservoir's operation, all the remaining wells were abandoned with DOGGR oversight in 1992-1995.

In 1942, the United States government had over 240 acres of the Playa del Rey oilfield converted to use as a natural gas storage field during World War II (ESA 2003). The natural gas storage field encompassed the 11 property clusters in Playa del Rey. After the war, in 1945, the storage field was transferred to the Reconstruction Finance Corporation which in turn sold the storage field in 1953 to SCG. In 1956, following construction of facilities for the Playa del Rey Natural Gas Storage Field, the injection and storage of natural gas in a zone about 6,200 feet below ground surface began. Today, SCG continues to inject, remove and store nature gas at the Playa del Rey Natural Gas Storage Field but no longer uses the 11 Playa del Rey wells that are a part of this Site in these operations.

The natural gas stored in the below-ground reservoir is brought in by pipeline from other gas production fields and is used as a "supply cushion" to provide extra natural gas to consumers during times of peak demand. Impermeable layers of rock provide a natural cap to the gas storage field. SCG used the oil wells in the Playa del Rey area as portals into the underground storage field to inject and remove the natural gas, to monitor the reservoir and its pressure, to remove oil and water from the storage reservoir, and to monitor for leakage outside the reservoir area. In 1955-1956, SCG opened up 6 of the eight previously abandoned Playa del Rey wells for use in their storage operations. Two of these wells were re-abandoned in 1956 and 1958 to standards current at that time, and were never used in the SCG gas storage operations. The Playa del Rey wells used by SCG in their gas storage operations were primarily used as observation and fluids removal wells. When it was determined that they were not vital to the storage reservoir's operation, they were abandoned with DOGGR oversight in 1992-1995.

The well located in Marina del Rey (Troxel-1) was drilled in 1930 and produced oil from that time until 1993. It was not a part of the Playa del Rey Natural Gas Storage field, but was acquired to monitor natural gas migration to the north, according to SCG internal correspondence. At the time of its abandonment in 1993, it was still producing gas and crude oil, reportedly from a different zone than that use for the storage reservoir. The well was re-abandoned in 1994 with DOGGR oversight and approval after natural gas was detected in the area of the well.

1.2 Site Investigation and Data Collection

In 2003, Brown and Caldwell conducted an environmental assessment to evaluate the presence of petroleum hydrocarbons in soil and soil vapor at all 12 lots and also the shallow groundwater at Cluster 12, Troxel. The results of this environmental assessment are documented in Brown and Caldwell's *Report on the Results of Environmental Site Assessment Activities* which was submitted to the CPUC under a separate cover (Brown and Caldwell 2004). This report and others created in preparation of the Environmental Impact Report are available from the CPUC upon written request.

The purpose of the studies was to collect samples of soil, soil vapor and groundwater for analysis for TPH and chemicals of most concern to human health: benzene, ethylbenzene, toluene and xylenes and semivolatile organic chemicals that can be found in TPH. The sample locations were selected based on likelihood of the presence of impacted soil, soil vapor or groundwater. The study was conducted in three phases of gathering data to assure that the samples would be representative of the "worst-case" areas of impact. The results of one phase were used to focus the sampling for the next phase in areas where the highest concentrations were found. The phases of the assessment activities carried out were:

Phase	Scope of Phase
Phase I: June 2003	Soil vapor samples were collected from 133 locations (a minimum of 4 from each of the 36 lots) from depths of 5 to 10 feet. Each location was tested only once and is called the temporary soil vapor sampling location in this risk assessment. Temporary soil vapor sampling points can only be sampled one time. The purpose was to use the results of the temporary sampling points to locate the permanent soil vapor sampling points in Phase 2 in the locations of highest impact. However, the information from these temporary soil vapor sampling locations was also included in the risk assessment.
Phase II: July 2003	Playa del Rey Property Clusters: a) Soil samples were collected every 5 feet from 34 locations to depths of 30 feet below grade from borings made with a hollow-stem auger in the 11 property clusters. b) Soil samples were collected from one 80-foot soil boring to assess deeper soil physical and chemical properties. c) Fourteen soil vapor monitoring points were installed, with at least one for each cluster. d) Select soil samples were submitted from each borehole for both geotechnical and chemical analyses. Marina del Rey Property Cluster: a) Soil samples were collected every 5 feet at five locations by boring into the soil using hollow-stem auger drilling methods (with continuous coring from 25 to 35 feet). b) Five groundwater wells were installed by converting four borings to 20 foot depth and a 45-foot boring were converted to groundwater monitoring wells. c) A semi-permanent soil vapor well was installed in one additional soil boring hand-augered to approximately 8 feet bgs. d) Soil samples were collected from one deep (60 feet) soil boring made using mud rotary drilling techniques to assess deeper soil physical and chemical properties. e) Select soil samples were submitted from each boring location for both geotechnical and chemical analysis.
Phase III: August through December 2003	Four soil vapor sampling events were conducted at select well locations (12 plus one additional for the nested well at Cluster 11) from the 14 semi-permanent soil vapor monitoring points. At each event, at least one vapor well was monitored from each property cluster, and the selected well was the one closest to the former oil well. Four groundwater sampling events were conducted at the monitoring wells at the Marina del Rey property cluster.

The laboratory data for all samples from the investigation are included in Appendix A. Each sample (soil vapor or soil) was given a unique designation code that was recorded in the field logbook, on the sample/core log, on the label affixed to the sample container, and on the chain-of-custody record. For soil vapor and soil samples, the first set of characters represented the cluster identification, the next set identified the lot number, the following set denoted the soil vapor or boring number, and the last set of characters was the sample depth interval in the boring in feet bgs. An example of a sample designation is as follows:

C1-L1-SG1-10	where	C1	= Cluster 1
		L1	= Lot 1
		SG1	= Soil Gas Probe 1
		10	= 10-foot sample interval depth (feet below grade)

2.0 DATA EVALUATION

In the Data Evaluation, the results from laboratory analysis (data) of concentrations of chemicals identified in environmental media (groundwater, soil and soil vapor) samples are reviewed to develop a list of chemicals identified in the samples. These chemicals are all included in the risk assessment calculations and are called chemicals of potential concern. In the next section, Exposure Assessment, the data on concentrations of chemicals in environmental media are converted into estimated exposure concentrations with which people could come into contact.

The historic uses of all the lots involved oil and natural gas production and storage. The samples collected were analyzed to determine the presence of TPH, the volatile organic chemicals (with benzene, toluene, ethylbenzene, and xylenes being the only volatile organic chemicals detected) and semi-volatile organic chemicals.

Methane and hydrogen sulfide are two gases that are included in investigations conducted by other members of the ESA team that are not included in the human health risk assessment as mentioned on page 2. However, the reports that address methane from Methane Specialists and hydrogen sulfide from Gary Boettcher were prepared along with this risk assessment as part of the Environmental Impact Report. These reports are listed in the references and are available from the CPUC upon written request.

Hydrogen sulfide was not included in the risk assessment because there is no evidence that hydrogen sulfide in outdoor air is elevated due to releases from the vapors at the lots. This evidence is documented in a report by Gary Boettcher (Boettcher 2004).
Methane is not included because it is not known to have long term health effects below the concentrations where it acts as an asphyxiant (replaces oxygen) and is explosive. The latter hazards associated with methane are discussed separately in a report prepared by Methane Specialists, another member of the ESA team (Methane Specialists 2004).

The data were evaluated to determine if any samples or data points might not be usable for risk assessment calculations. Risk assessment protocols acknowledge that some data that meet the standards required for validation of laboratory and field methods may not be suitable for the risk assessment. The usability of the data was evaluated based on the presence of elevated detection limits, laboratory data qualifiers and the detection of any chemical in the associated sample blanks in accordance with U.S. EPA guidance (U.S. EPA 1989).

The data collected during the recent investigation are presented in Appendix A and were found to be usable in the risk assessment. There were no issues with data quality.

2.1 Soil Samples

The sample results used in the risk assessment include 86 soil samples (48 of which were collected from depths of 15 feet or less below ground surface) (Appendix A). Duplicate samples are included in this count. TPH was analyzed by molecular weight groupings. Figures 2.1.1 and 2.1.2 depict the locations and results of all soil samples in which any of the chemicals were detected for the Playa del Rey and Marina del Rey property clusters, respectively. The figures only present the results for samples where at least one chemical was detected. There are many more samples than represented on these figures. Hydrocarbons were detected in 16 of the 48 0 to 15 foot-depth samples. As explained in Section 3.0, the zone from the surface to 15 foot-depth is the mostly likely exposure depth. Additional information on the groupings and the nature of these hydrocarbon chemicals is presented in Section 3.1. In the soil samples, gasoline was not identified in any sample nor was the individual components of gasoline (benzene, ethylbenzene, toluene and xylene). There were five samples analyzed for semivolatile organic chemicals but none were identified.

2.2 Temporary and Semi-Permanent Soil Vapor Samples

The sample results used in the risk assessment include 175 samples from temporary vapor sampling locations conducted during the first phase of the Brown and Caldwell investigation (Appendix A) and 56 samples from 12 semi-permanent vapor monitoring wells (one of which has 2 sample depths) conducted during the third phase of the Brown and Caldwell investigation. Duplicate samples are included in this count.

The first phase of Brown and Caldwell's work included testing soil gas from 132 different locations on the property clusters. The results of detected samples from the temporary soil vapor survey are mapped on Figure 2.2.1 and Figure 2.2.2 for the Playa del Rey and Marina del Rey property clusters, respectively. In the temporary vapor sampling locations, benzene was not identified in any sample. The other chemicals, ethyl benzene, toluene, xylene and TPH as gasoline, were identified in a frequency ranging from two to 11 percent (20 samples). An exception to the number of analyses is xylene. Total xylenes includes the ortho, meta and para forms. There were 14 samples for total xylenes and 56 samples for two groupings of the forms, meta and para-xylenes (m,p xylene) and ortho-xylene (o-xylene). Duplicate samples are included. No chemicals were detected in the Marina del Rey property cluster.
The third phase of Brown and Caldwell's site investigation included the sampling of semi-permanent soil vapor monitoring points installed at each of the property clusters. Four rounds of sampling were conducted over 4 months during periods of varying temperature and pressure. The results of detected soil gas samples from the semi permanent monitoring wells are presented in Figures 2.2.3 and 2.2.4, for the Playa del Rey and Marina del Rey property clusters, respectively. In the permanent vapor sampling locations, all chemicals included in the analyses were identified in one or more samples with a frequency ranging from nine percent for benzene to 80 percent for toluene.

2.3 Groundwater

There are 21 samples of groundwater from five wells at Cluster 12, Troxel in Marina del Rey. Benzene, ethylbenzene, toluene, xylenes or TPH as gasoline were detected in most of the samples and the results are shown on Figure 2.3.1 and are tabulated in Appendix A.

3.0 EXPOSURE ASSESSMENT

The exposure assessment discusses the properties of the chemicals, identifies the activities that could bring people into contact with the chemicals (exposure scenarios), the concentration at the point of exposure and how much chemical they could take in (daily intake). Risk assessment methods are designed to estimate a reasonable maximum exposure over the lifetime to individuals who could live at the site.

3.1 Properties of Petroleum Chemicals

The ways that people could be exposed to chemicals depends on their chemical properties. The components of oil are called petroleum hydrocarbons. Petroleum hydrocarbons are complex mixtures of chemicals that range from chemicals like benzene that are light-weight chemicals with six carbons in the benzene ring up to complex heavier-weight chemicals with 36 to 40 carbons in the molecules. TPH is analyzed by molecular weight groupings: C6-C10 means the chemicals have six to 10 carbon atoms; C10–C22 means the chemicals have 10 to 22 carbon atoms and C22-C36 means the chemicals have 22 to 36 carbon atoms.

The molecular weight of the chemical can be use to predict how the chemical will behave in the environment. The lighter-weight chemicals from C6-C10 also include benzene, ethylbenzene, toluene and xylenes. These chemicals, collectively called BTEX, are volatile and evaporate easily into pores in the soil as soil vapor and then can migrate into indoor or outdoor air under some circumstances. These chemicals can be degraded by natural soil bacteria and often, the concentrations will be reduced or eliminated as the soil vapors migrate upwards. The heavier components of TPH can persist in soil and remain immobile in the soil or leach into the groundwater.

The understanding of vapor migration is a newly emerging risk assessment issue and is still controversial among scientists. Scientists do not agree on the circumstances under which vapors will migrate or on the natural processes in soil that could reduce the concentrations of chemicals in the soil vapor. For purposes of this risk assessment, the chemical vapors are assumed to migrate into indoor and outdoor air without any natural degradation processes reducing the concentration.

3.2 Exposure Scenarios

This section identifies the types of activities that could bring people into contact with the chemicals (exposure scenarios). An exposure scenario includes people who could come into contact with the chemicals (receptors) from their activities. All of the lots are vacant at this time. The lots are in residential neighborhoods so it can be assumed that future use will include single or multiple family residences.

Residents in the future could come into contact with chemicals in the indoor or outdoor air if vapors migrated from the groundwater, soil or underground storage units. Residents could also come into contact with chemicals that are found in soil. Contact with soil could lead to exposure via ingestion of soil, inhalation of soil particles in the air and dermal transfer of chemicals in soil in contact with the skin.

Groundwater is not used for drinking water in the neighborhoods of any of the lots. There is a possibility that utility or construction workers could get wet while working below the surface. Groundwater at Cluster 12, Troxel, is shallow, about eight to 11 feet below ground surface; however, it is not likely that anyone would come into contact with the groundwater. The potential for exposure due to dermal absorption of chemicals in groundwater is considered insignificant. Health and safety requirements for underground work generally restrict the amount of contact that workers can have with water in a trench. Also, any contact would only happen occasionally rather than on a regular basis.

In summary, the most likely ways that people could come into contact with chemicals in the future include:

- Inhalation of chemical vapors that have migrated into indoor or outdoor air from soil, groundwater or the underground storage units
- Ingestion of chemicals in soil
- Inhalation of chemicals on particles of soil
- Absorption of chemicals from soil on their skin

3.3 Exposure Point Concentrations

The exposure point concentration is an estimate of the amount of chemical that future residents could contact at the point of exposure. The maximum concentration of each chemical detected in any sample, regardless of location, was used to calculate the risk. The maximum concentrations are presented on Table 3-1 for soil, Table 3-2 for the soil vapor samples from the temporary sampling points and Table 3-3 for soil vapor samples from the permanent monitoring wells. Therefore, a hypothetical lot is created and the concentrations of chemicals in the soil and the soil vapor are represented by the maximum concentration found in any individual lot. This approach results in an upper estimate or worst case estimate of exposure. This means that exposure at any individual lot will be lower. For outdoor air, the risk characterization in Section 5.0 will also consider the collective risk for the vapor emissions from each of the 12 property clusters.
This approach is more protective than that recommended by U.S. EPA guidance (U.S. EPA 1989 and 2002). U.S. EPA recommends using an upper bound average concentration to estimate exposure because health risk is based on daily exposure over a lifetime.

For contact with chemicals in soil, the maximum concentration in the upper 15 feet was used. Risk assessment protocols for future use assume that construction in the future could bring deeper soil to the surface where people could come into contact with chemicals. Standard practice in California is to assume that the upper 10 feet is potentially available for exposure. For this risk assessment, to represent a protective assessment of exposure, the maximum concentration in the upper 15 feet was used. Additionally, although the BTEX compounds were not detected in soil, one half the detection limit was assigned as the exposure point concentration since these compounds were identified in soil vapor and groundwater. This adds another level of protection to the risk assessment.

The samples of soil gas collected from the permanent vapor monitoring wells and temporary soil gas sampling locations capture any chemical vapors from all sources including groundwater, soil and underground storage units. U.S. EPA recommends using the concentrations of chemicals in soil vapor to estimate migration to indoor air. Additionally, although benzene was not detected in the samples collected from the temporary soil vapor sampling locations, one half the detection limit was assigned as the exposure point concentration since benzene was identified in soil vapor samples collected from the permanent vapor wells and groundwater. This adds another level of protection to the risk assessment.

Concentrations of chemicals in indoor air (Table 3-4) were estimated using the maximum concentrations of each chemical in any soil vapor sample and the Johnson and Ettinger model (U.S. EPA 2003a and 2003b). The Johnson and Ettinger model estimates the concentration of a chemical that could migrate into a building through cracks in the foundation. This model is theoretical and has not been fully field validated. The U.S. EPA and Cal/EPA recommend the Johnson and Ettinger model and it is the only widely-used model for migration of vapors to indoor air. However, scientists are not in agreement that this or any model is adequate to predict vapor migration. Modeling input and output for the Johnson and Ettinger model are presented in Appendix B.

The following site-specific input values were used along with default model parameters for indoor and outdoor air:

- soil gas sampling depth — 304.8 centimeters (cm) (10 feet bgs)
- soil type — sand
- vadose zone soil dry bulk density — 1.61 grams per cubic centimeter (site-specific sample results)
- vadose-zone soil total porosity — 0.397 (site-specific sample results)
- vadose-zone soil water-filled porosity — 0.078 cubic centimeter per cubic centimeter (site-specific sample results)
- average soil temperature — 20 degrees Celsius (site-specific)
- residential air exchange rate — 0.66 (site specific) (Murray et al. 1995)

Concentrations of chemicals in outdoor air (Table 3-5) were estimated using the maximum concentration of the chemical found in any soil sample and the equations presented in Appendix C from the PEA guidance document (Cal/EPA 1994).

3.4 Estimation of Daily Intake

Daily intake is the amount of chemical that a receptor could potentially take in as a result of exposure. Daily intake rates are estimated by combining estimates of how much air people typically breathe each day and how much soil they contact. The parameters used to estimate intake are called exposure assumptions. Exposure assumptions are designed to estimate a reasonable maximum exposure. In other words, a level of exposure that is higher than is reasonably likely to occur so that if any exposure does occur, it is expected to generally be less than these estimates.

The exposure assumptions describe a hypothetical resident adult and child who are assumed to spend the majority of their time in situations that could bring them in contact with the chemicals. Residents are assumed to be in contact with the chemicals for 350 days a year for 30 years, 6 years as a child and 24 years as an adult. Each day, a hypothetical resident inhales air for 24 hours a day. The exposure to indoor and outdoor air is calculated separately so that the risk for indoor air and outdoor air can be viewed independently. Exposure to soil is also assumed to occur daily. The specific exposure assumptions were compiled from the PEA guidance document (Cal/EPA 1994) and are presented in Table 3-6.

The general equation for calculating intake is shown below:

$$D = (C \times CR \times EF \times ED) / (BW \times AT)$$

where

D	=	daily intake (milligrams per kilogram per day)
C	=	exposure point concentration (milligrams per kilogram [mg/kg])
CR	=	contact rate (kilograms per day)
EF	=	exposure frequency (days per year)
ED	=	exposure duration (years)
BW	=	body weight (kilograms)
AT	=	averaging time (days)

4.0 TOXICITY ASSESSMENT

In the toxicity assessment, information on the potential health effects of the chemicals identified in environmental media are evaluated and toxicity factors from appropriate sources are identified. Toxicity factors represent the properties of the chemicals that could cause an adverse health effect.

The toxicity factors are combined with the dose from the exposure assessment in the next section, Risk Characterization, to estimate the likelihood of an adverse health effect. Toxicity factors are presented in Table 4-1. Toxicity profiles are presented in Appendix D.

There are two types of toxicity factors: slope factors for chemicals that are known or potential carcinogens and reference doses for noncarcinogenic health effects. These health effects are discussed in more detail in this section. An individual chemical can have both a slope factor and a reference dose. The only chemical in this category is benzene. Benzene is the only chemical identified that is considered a carcinogen. Benzene also has a reference dose for noncancer health effects.

Toxicity factors that have been established by groups of doctors and scientists were selected from peer-reviewed sources. The following hierarchy was used to identify toxicity factors:

1. Cal/EPA Toxicity Values (Cal/EPA 2003)

2. U.S. EPA Region IX Preliminary Remediation Goals (U.S. EPA 2002) which includes toxicity data from the following sources and includes the applicability of route to route extrapolation:

   - Integrated Risk Information System (U.S. EPA 2003c);
   - Health Effects Assessment Summary Tables (U.S. EPA 1997); and
   - National Center for Environmental Assessment.

4.1 Toxicity Factors for Carcinogens

The toxicity factor for carcinogens is the slope factor. Slope factors are expressed in (mg/kg of body weight per day)$^{-1}$. Slope factors are developed with a mathematical model that extrapolates data from laboratory animals exposed to high doses to estimate the probability of an increased incidence of cancer in humans exposed to much lower doses. The laboratory animals are exposed to the maximum dose that they can tolerate for relatively short periods in the laboratory, but human receptors would be exposed to very low levels over long periods. Slope factors are used to estimate the probability that an individual will have an increased risk of cancer above their baseline risk.

4.2 Toxicity Factors for Noncarcinogenic Effects

The potential for noncarcinogenic health effects is estimated using a toxicity factor known as the reference dose (RfD). Each RfD is associated with a specific health effect (e.g., central nervous system damage), also referred to as a toxicity endpoint.

The current scientific view assumes that for noncarcinogenic health effects, there is a concentration below which there is little potential for adverse health effects over the exposure period. That concentration is referred to as the threshold concentration. RfD are derived from either occupational exposure or animal studies and are adjusted using uncertainty factors. The RfD is calculated from the highest chronic (long-term) exposure level that did not cause adverse effects in the population (human or laboratory animal) studied. A safety factor is applied to this level to allow for any uncertainty, such as using data on animals to predict effects on humans. These factors range up to 10,000 based on the confidence level associated with the data.

Currently, neither Cal/EPA or U.S. EPA has derived toxicity factors for petroleum hydrocarbon mixtures. However, the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), Toxicology Technical Action Group has developed toxicity factors for petroleum hydrocarbon fractions. This methodology is consistent with that used by Cal/EPA and U.S. EPA to derive toxicity factors for other chemicals. The TPHCWG is a consortium of private and public organizations, including state regulatory agencies, academia, the Department of Defense, Department of Energy, Agency for Toxic Substances and Disease Registry, the U.S. EPA, the petroleum, power and transportation industries, and consulting firms. The TPHCWG methodology is published in the document Development of Fraction-Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPHCWG 1997). The methodology is used in this assessment to develop RfDs for the three groups of TPH measured in the samples of environmental media.

TPH compounds are divided into two categories: aromatic and aliphatic. Aromatic compounds are hydrocarbons that are arranged in a ring structure. The most common and important aromatic compounds are benzene, ethylbenzene, toluene and xylene. These chemicals are considered among the most toxic components of TPH and were analyzed for separately in the environmental media. The chemicals measured in the TPH are assumed to be aliphatic hydrocarbons (arranged in a linear structure). These chemicals are known to have only non-cancer effects. The RfDs recommended by the TPHCWG are used in this risk assessment (Table 4-1).

5.0 RISK CHARACTERIZATION

The final step in the risk assessment process is the characterization of risk, in which exposure and toxicity information are combined to evaluate potential health risks. In this section, the daily intake from the exposure assessment is combined with the toxicity factor from the toxicity assessment to estimate the likelihood of a health risk. Equations from the PEA guidance document (Appendix C) were used to calculate the cancer risk and hazard indices. A summary of the risks is presented in Table 5-1.

5.1 Overview of Cancer Risk

Cancer risk is described as the individual excess cancer risk (cancer risk) and is expressed as a probability. It is an estimate of the probability that the hypothetical individual who has the level of exposure described by this risk assessment would have an increased risk in cancer incidence. Cancer risk does not predict actual cases of cancer. A risk of $1x10^{-6}$ means that there is a probability of 1 in a million of increased incidence of cancer above the baseline or normal cancer rate.

Cal/EPA and U.S. EPA have established a range of acceptable cancer risks of $1x10^{-4}$ to $1x10^{-6}$ for Superfund Sites. This means that cancer risk levels should be between an upper limit of 1 in 10,000 probability to a de minimis level of 1 in 1,000,000. Cancer risk below 1×10^{-6} are considered negligible. Cancer risk for different chemicals in the same exposure pathways are added together to assess the cumulative risk for exposure to multiple chemicals. Also, cancer risks for each exposure pathway are added together to determine the risk associated with exposure to all the chemicals and routes of exposure.

This risk assessment, using the maximum detected concentration for exposure, is designed to over-estimate the potential for risk so that any actual risk, if any is present, will be less than the calculated risks, and, in fact, may be zero.

5.2 Overview of Noncarcinogenic Health Effects

Noncarcinogenic health effects are expressed as the ratio between the daily intake and the reference dose. The reference dose is defined as a level of daily exposure that is unlikely to result in noncarcinogenic adverse health effects over a lifetime of exposure. Hence, hazard values greater than 1 indicate that exposure is greater than the recommended level, while hazard values less than 1 show that exposure is lower than the recommended level.

Hazard values for individual chemicals are called hazard quotients and those for several chemicals added together are called hazard indices. Hazard indices for each pathway were added together to assess the overall potential for noncarcinogenic adverse health effects although, in accordance with U.S. EPA guidance, it is only appropriate to add hazard quotients for chemicals that affect the same target organ. The hazard indices in this risk assessment will tend to overestimate noncancer health effects for this reason.

5.3 Risk Characterization Results

The estimated probability of an increased incidence of cancer for the residential future use scenario assuming 30-year exposure to the maximum chemical concentration found in any sample at any property cluster is 4×10^{-7}. The estimated noncarcinogenic hazard index is 0.6. Both these values are below Cal/EPA and U.S. EPA levels of no-significant risk. The cancer risk is 2.5 times lower than the no-significant risk level and the noncarcinogenic hazard index is more than 1.5 times lower than the recommended level.

Table 5-2. Total Cancer Risk and Hazard Index

Exposure Pathway	Cancer Risk	Hazard Index
Contact with soil (ingestion and dermal)	9×10^{-10}	0.09
Inhalation of outdoor air	2×10^{-9}	0.06
Inhalation of indoor air	4×10^{-7}	0.5
TOTAL	$\mathbf{4 \times 10^{-7}}$	**0.6**

Inspection of this table also shows that the collective impact of all lots on the outdoor air is minimal. In a worst-case situation, if all lots emitted vapors to the outdoor air at the maximum concentration and the risks were multiplied by at factor of 12, the cancer risk and noncancer hazard would still be below the risk management levels.

6.0 UNCERTAINTY ANALYSIS

The uncertainty analysis discusses the level of confidence that can be placed in the results of the risk assessment including, but not limited to, the adequacy of the sampling and resulting data, the omission of any chemicals from the quantitative risk assessment, the exposure assumptions, the calculation of exposure point concentrations, the sensitivity of fate and transport models, uncertainty around toxicity factors and risk characterization.

Risk assessments do not estimate actual health effects risks but are intended for use as a decision-making tool indicating, in a relative sense, the chemicals or types of exposure that could contribute the most risk. Risk assessments are used to help determine if the risks associated with exposure warrant corrective action. Such decisions depend not only on the calculated risk estimates, but also on the uncertainties and assumptions incorporated into the risk estimates. Accordingly, we provide a discussion of the more important uncertainties.

The uncertainties associated with each chapter in the risk assessment and their potential effects on the numerical risk estimates are discussed below.

6.1 Data Evaluation

Uncertainties are associated with the collection, analysis and evaluation of environmental data regarding the chemicals of potential concern selected for use in the risk assessment. The sampling plan used for this risk assessment is considered adequate to address the completed exposure pathways. The samples collected were collected from locations known or suspected to be impacted by chemicals. These samples were analyzed for TPH and the volatile organic chemicals including benzene, toluene, ethylbenzene, and xylene, and semivolatile organic chemicals. The laboratory results for these chemicals include 86 soil samples (48 of which are at or above 15 feet below ground surface), 231 soil vapor samples and 21 groundwater samples.

6.2 Exposure Assessment

An area of uncertainty in exposure assessment is the prediction of human activities that lead to contact with environmental media and exposure to chemicals and the models used to calculate these exposure concentrations. Activities that differ from those used in the exposure assessment could lead to higher or lower risks than those estimated. To compensate for this uncertainty, estimates of exposure were used that tend to overestimate exposure. Therefore, if some of the activities do not occur or occur for shorter periods of time than the estimates used in this risk assessment, the risks presented here would be higher than any actual risk.

The standard approach to estimating the exposure concentration is to use a weighted average of all the concentrations measured in each sample in the exposure unit. This is because health risk is based on a lifetime average. In this risk assessment, the exposure concentration is based on the maximum concentration of each chemical for each pathway, regardless of where the chemical was detected. This is a highly protective assumption because this means that the maximum concentration was assumed to be present throughout the media, e.g., soil, soil vapor, and was assumed to not decrease in concentration for the exposure period of 30 years for residents.

There is uncertainty associated with the reliability of modeling vapor migration, particularly at Cluster 12, Troxel, where groundwater is shallow (eight to 11 feet below ground surface). Benzene and other volatile chemicals were identified in the groundwater at Cluster 12 but not in the soil vapor. It may be that the volatile chemicals are naturally degraded and do not migrate upwards or it may be that vapors would migrate into a home built on this lot. In this risk assessment the benzene concentration in soil gas at Cluster 12 was assumed to be equal to the greatest concentration detected in any of the lots.

6.3 Toxicity Assessment

Use of cancer slope factors and reference doses are subject to several types of uncertainties. Typically, the studies from which these values are derived involve conditions that are not identical to the types of exposures of interest. Extrapolations from animal experiments to human health effects are frequently required to derive a toxicity value for use in risk assessment. The mathematical models used in the extrapolations are designed to be protective but there is a level of uncertainty in these models as there is limited means to verify the models.

The toxicity of each chemical was assumed to be additive. Interactions between chemicals, synergisms or antagonisms, were not accounted for because there is limited toxicity information on these types of interactions. Therefore, attempting to account for interactions could result in over- or under-estimations of the risks.

Benzene is the only chemical that is a known human carcinogen or Class A carcinogen. Benzene has been shown to cause cancer in occupational settings to workers who use it routinely at high concentrations.

6.4 Risk Characterization

The results of the risk assessment found that the cancer risk and noncancer hazard indices are well below levels considered insignificant by federal and state agencies. Every effort has been made to compensate for the inherent uncertainties in risk assessment. However, there is controversy around the reliability of the model that both the U.S. EPA and Cal/EPA use (the only model for vapor intrusion) use to predict vapor migration.

This risk assessment recommends mitigation measures be considered in the Environmental Impact Report prepared such as those required by the Los Angeles City Building Code Section 91.106.4.1 and Division 71 of Article 1, Chapter IX of the Los Angeles Municipal Code. This code requires mitigations for methane and other gases be implemented when future construction occurs at these sites. These measures include the installation of vapor membrane barriers and vent piping as well as trench dams and electrical seal offs. .

7.0 REFERENCES

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*There reports are available from the California Public Utilities Commission upon written request.

TABLES

Table 3-1
Maximum Concentrations of Chemicals in Soil (0-15 feet bgs)

Chemical	Maximum Concentration	Location of Maximum	Number of Samples	Number of Non-Detects
TPH (C6-C10)	12	C8-L23-B3-5	48	45
TPH (C10-C22)	300	C10-L7-B2-5	48	45
TPH (C22-C36)	770	C6-L29-B1-5	48	35
Benzene*	0.0025	na	48	48
Toluene*	0.0025	na	48	48
Ethylbenzene*	0.0025	na	48	48
Xylenes*	0.0025	na	48	48
Gasoline*	1.5	na	48	48

All concentration presented in milligrams chemical (mg) per kilograms soil (kg); equivalent to parts per million (ppm)

* In order to include chemicals detected in some media but in all media, 1/2 the detection limit was used as the maximum concentration when the chemical was not detected in any

This table presents the maximum soil concentrations. These data are used to evaluate the direct contact pathway (ingestion of soil, inhalation of vapors and particles in outdoor air) and to calculate concentrations of chemicals in outdoor air in the exposure assessment .

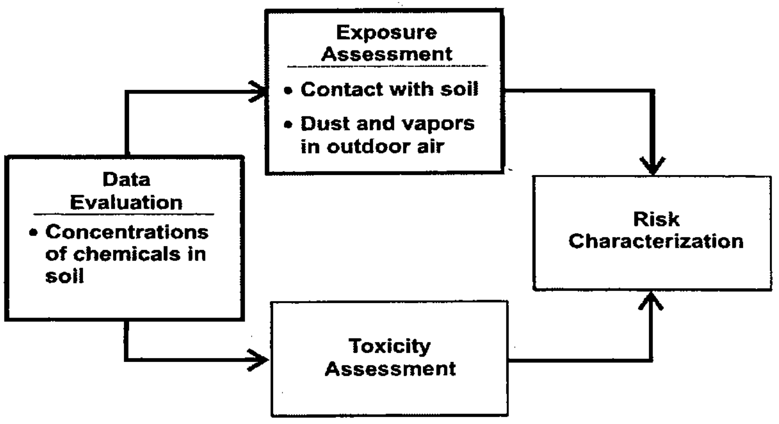


Table 3-2
Maximum Concentration of Chemicals in Soil Vapor from Temporary Vapor Sampling Points

Chemical	Molecular Weight	Maximum Concentration µg/L	Maximum Concentration ppbv	Location of Maximum	Number of Samples	Number of Non-Detects
Benzene*	78.1	0.5	154	na	175	175
Toluene	92	1.8	471	C2-L3-SG2-10'	175	171
Ethylbenzene	106.2	12	2,718	C2-L3-SG4-10'	175	163
m- and p-Xylene	106.2	56	12,682	C2-L3-SG4-10'	175	155
o-Xylene	106.2	16	3,623	C2-L3-SG4-10'	175	163
Gas Range Organics	na	240	nc	C3-L15-SG1-10'	175	163

$$X\ \text{ppbv} = \frac{Y\,\frac{\mu g}{L} \times 24.05 \times 1000}{MW}$$

* The maximum concentration is based on 1/2 the detection limit because benzene was not identified in any sample

µg/L - micrograms per liter
nc - not calculated because it is not possible to estimate a molecular weight for a complex mixture
ppbv - parts per billion by volume

This table presents the maximum soil vapor concentrations identified in the temporary wells and shows how the units of microgram per liter of air (ug/L) were converted to parts per billion by volume (ppbv). These data are used to calculate concentrations of chemicals in indoor air in the exposure assessment .

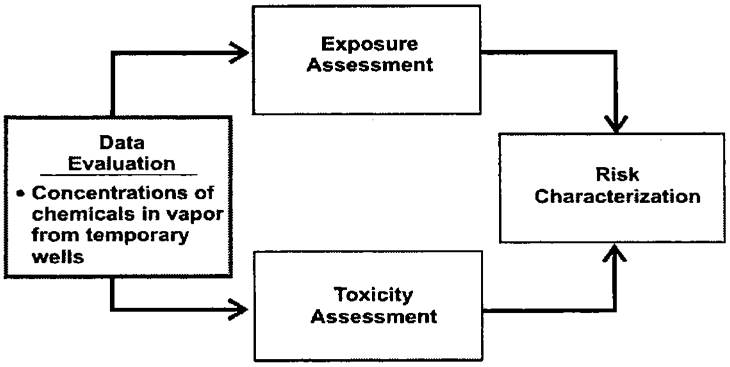


Table 3-3
Maximum Concentrations of Chemicals in Soil Vapor from Permanent Vapor Wells

Chemical	Maximum Concentration	Location of Maximum	Number of Samples	Number of Non-Detects
Benzene	23	C11-L19-VW2-Shallow	56	51
Ethylbenzene	9.3	C11-L19-VW2-Shallow	56	41
m, p-Xylene	12	C11-L19-VW2-Shallow	56	32
o-Xylene	4.2	C11-L19-VW2-Shallow	56	43
Toluene	18	C11-L19-VW2-Shallow	56	11
Xylene	14	C11-L19-VW2-Shallow	14	7
TPH-g (ppmv)	100	C11-L19-VW2-Shallow	56	49
TPH-g (ug/L)	370	C11-L19-VW2-Shallow	56	49

All concentration presented in ppbv except where noted.

µg/L - micrograms per liter
ppbv - parts per billion by volume
ppmv - parts per million by volume

This table presents the maximum soil vapor concentrations identified in the permanent wells. These data are used to calculate concentrations of chemicals in indoor air in the exposure assessment .

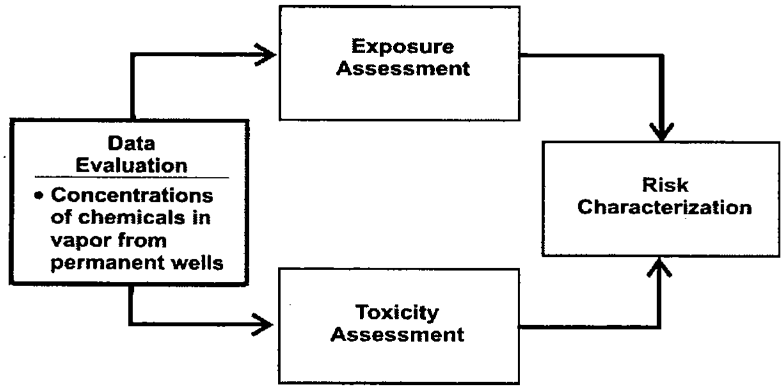


Table 3-4
Estimated Concentrations of Chemicals in Indoor Air

Chemical	Maximum Concentration in Soil Gas/Vapor ppbv	Indoor Air µg/m³
Benzene	23	2.36E-02
Ethylbenzene	2,718	3.40E+00
m, p-Xylene	12,682	1.61E+01
o-Xylene	3,623	5.01E+00
Toluene	471	5.65E-01
Xylene	14	nc
Gas Range Organics (µg/L)	240	nc
TPH-g	100,000	nc
TPH-g (ug/L)	370	nc

ppbv - parts per billion by volume
µg/m³ - micrograms per cubic meter
nc - not calculated because chemical specific input parameters are not available to allow modeling of vapor migration

This table presents the maximum soil vapor concentrations from either the temporary (Table 3-2) or permanent (Table 3-3) wells and the indoor air concentrations calculated using the Johnson and Ettinger Indoor Air Model. The indoor air concentrations were used to evaluate the indoor air pathway.

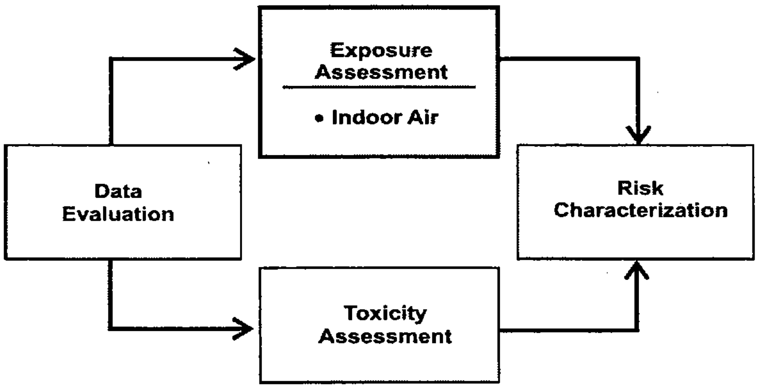


Table 3-5
Estimated Concetrations of Chemicals in Outdoor Air

Chemical	Bulk Soil Concentration[1]	Hc	Koc	foc	Kd	Di	Ei	Ca
TPH (C6-C10)	1.2E-05	8.00E-01	631	0.02	12.6	0.1	2.6E-01	2.6E-03
TPH (C10-C22)	3.0E-04	1.27E+01	50118	0.02	1002	0.1	2.5E+00	2.5E-02
TPH (C22-C36)[2]	7.7E+02							3.9E-05
Benzene	2.5E-09	5.43E-03	65	0.02	1.3	0.088	1.1E-05	1.1E-07
Toluene	2.5E-09	5.94E-03	257.04	0.02	5.1	0.078	5.4E-06	5.4E-08
Ethylbenzene	2.5E-09	8.44E-03	220	0.02	4.4	0.075	6.8E-06	6.9E-08
Xylenes	2.5E-09	5.30E-03	240	0.02	4.8	0.087	5.6E-06	5.6E-08

1. Bulk soil concentration = maximum concentration of chemical in soil, mg/kg x (10^{-6} kg/mg)
2. Concentration presented as is (i.e., no multiplication by 10^{-6})

TPH - total petroleum hydrocarbons
mg/kg - milligrams per kilogram
kg/mg - kilograms per milligram

Hc - chemial-specific Henry's Law Constant (atmospheres-cubic meter per mol, atm-m^3/mol)
Koc - chemial-specific organic carbon to water partition coefficient (liters per kilogram, l/kg)
foc - fraction organic carbon in soil (PEA default = 0.02)
Kd - soil-water partition coefficient, (cubic centimeter per gram, cm^3/g)
Di - diffusion coefficient in air of chemical (centimeter squared per second, cm^2/sec)
Ei - average emission rate of chemical over the residential lot during the exposure interval (milligram per second, mg/sec)
Ca - concentration in air (milligrams per cubic meter, mg/m^3)

Chemical specific values for benzene, toluene, ethylbenzene, and xylenes were compiled from the PEA document.
Hc for the TPH fractions obatained from TPHCWG - Volume 5

This table presents the maximum soil concentrations and shows the calculation of the outdoor air concentrations using equations from the California Preliminary Endangerment Assessment (PEA) Guidance Document. The outdoor air concentrations were used to evaluate the outdoor air pathway.

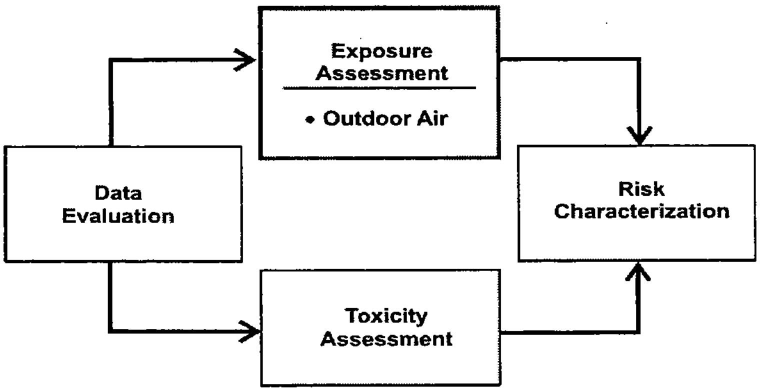


Table 3-6
Exposure Assumptions for Daily Intake

Pathway	Parameter	Resident Child	Resident Adult
Inhalation Of Volatilized Gases	IR - Inhalation Rate (m^3/day)	10	20
	EF - Exposure Frequency (day/yr)	350	350
	ED - Exposure Duration (yr)	6	24
	BW - Body Weight (kg)	15	70
	AT - Averaging Time, Carcinogen (days)	25550	25550
	AT - Averaging Time, Noncarcinogen (days)	2190	na
Inhalation Of Particulates	IR - Inhalation Rate (m^3/day)	10	20
	EF - Exposure Frequency (day/yr)	350	350
	ED - Exposure Duration (yr)	6	24
	BW - Body Weight (kg)	15	70
	AT - Averaging Time, Carcinogen (days)	25550	25550
	AT - Averaging Time, Noncarcinogen (days)	2190	na
Incidental Ingestion of Soil	IR - Ingestion Rate (mg/day)	200	100
	EF - Exposure Frequency (day/yr)	350	350
	ED - Exposure Duration (yr)	6	24
	BW - Body Weight (kg)	15	70
	AT - Averaging Time, Carcinogen (days)	25550	25550
	AT - Averaging Time, Noncarcinogen (days)	2190	na
	CF - Conversion Factor (kg/mg)	1E-6	1E-6
Dermal Contact with Soil	SA - Surface Area (cm^2/day)	2000	5800
	ABS - Absorption Coefficient	CSV	CSV
	AF - Adherence Factor (mg/cm^2)	1	1
	EF - Exposure Frequency (day/yr)	6	24
	ED - Exposure Duration (yr)	350	100
	BW - Body Weight (kg)	15	70
	AT - Averaging Time, Carcinogen (days)	25550	25550
	AT - Averaging Time, Noncarcinogen (days)	2190	na
	CF - Conversion Factor (kg/mg)	1E-6	1E-6

cm^2/day - centimeter squared per day
CSV - chemical-specific value
day/yr - days per year
kg - kilogram
kg/mg - kilograms per milligram
m^3/day - cubic meters per day
mg/cm^2 - milligrams per sqaured centimeter
mg/day - milligrams per day
yr - years

Source: DTSC (1994) - Preliminary Endangerment Assessment, January 1994

This table presents the exposure assumptions that describe the amount time time that people could come into contact with chemicals and the amount of chemical they might take into their bodies. The equations used to calculate daily intake are presented in Appendix 3.

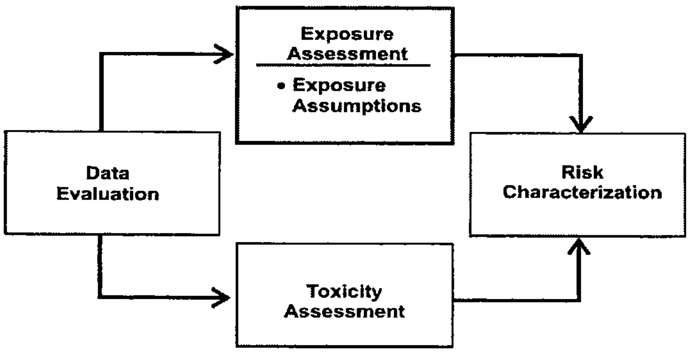


Table 4-1
Toxicity Factors

Chemical	RfDo (mg/kg-day)	RfDi (mg/kg-day)	CSFo $(mg/kg\text{-}day)^{-1}$	CSFi $(mg/kg\text{-}day)^{-1}$
Benzene	4.0E-03	8.6E-03	1.0E-01	1.0E-01
Toluene	2.0E-01	1.1E-01	na	na
Ethylbenzene	1.0E-01	2.9E-01	na	na
m-, p-Xylene	2.0E-01	2.9E-02	na	na
o-Xylene	2.0E-01	2.9E-02	na	na
TPH (C6-C10)	1.0E-01	2.9E-01	na	na
TPH (C10-C22)	1.0E-01	2.9E-01	na	na
TPH (C22-C36)	2.0E+00	2.0E+00	na	na

RfDo - oral reference dose in milligrams per kilogram per day (mg/kg-day)
RfDi - inhalation reference dose in milligrams per kilogram per day
CSFo - oral cancer slope factor in (milligrams per kilogram per day)$^{-1}$ (mg/kg-day)$^{-1}$
CSFi - inhalation cancer slope factor in (milligrams per kilogram per day)-1
na - not applicable (no toxicity value has been established by Cal/EPA or U.S. EPA)

This table presents the toxicity factors developed by U.S.EPA and Cal/EPA to represent the potential cancer and noncancer health effects of the chemicals. These factors are combined with the chemical concentrations in soil, indoor air and outdoor air and the exposure assumptions to calculate the risk to human health.

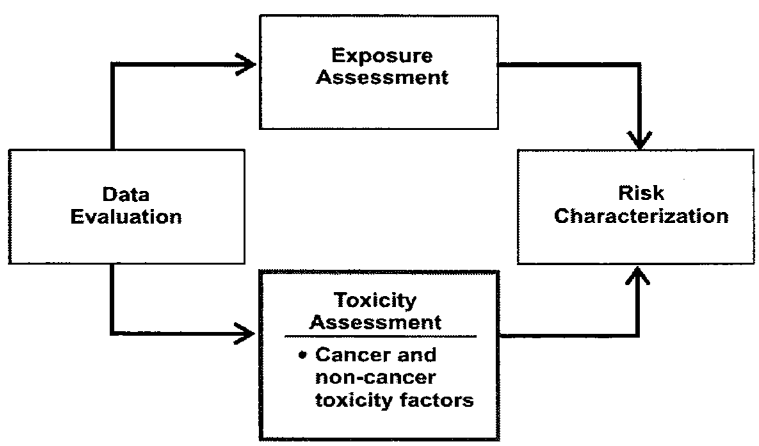


Table 5-1
Summary of Cancer Risks and Hazard Indices

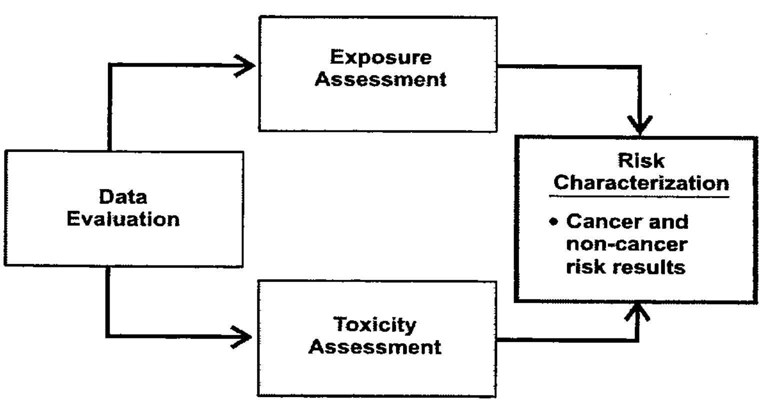
Chemical	Cancer Risk			Hazard Index		
	Soil	Outdoor Air	Indoor Air	Soil	Outdoor Air	Indoor Air
Chemicals Identified in Soil Vapor Samples (used to estimate indoor air risk)						
Benzene	---	---	4×10^{-7}	---	---	0.002
Toluene	---	---	na	---	---	0.003
Ethylbenzene	---	---	na	---	---	0.007
m-, p-Xylene	---	---	na	---	---	0.4
o-Xylene	---	---	na	---	---	0.1
Chemicals Identified in Soil Samples (used to estimate risk from direct contact with soil and outdoor air)						
Benzene	9×10^{-10}	2×10^{-9}	*	0.00002	0.000008	*
Toluene	na	na	*	0.0000003	0.0000003	*
Ethylbenzene	na	na	*	0.0000006	0.0000002	*
Xylenes	na	na	*	0.0000003	0.000001	*
TPH (C6-C10)	na	na	*	0.003	0.006	*
TPH (C10-C22)	na	na	*	0.08	0.06	*
TPH (C22-C36)	na	na	*	0.01	0.00001	*
TOTAL	9×10^{-10}	2×10^{-9}	4×10^{-7}	**0.09**	**0.06**	**0.5**

Total Cancer Risk 4×10^{-7} **below the State and Federal Level of No-Significant Risk of** 1×10^{-6}

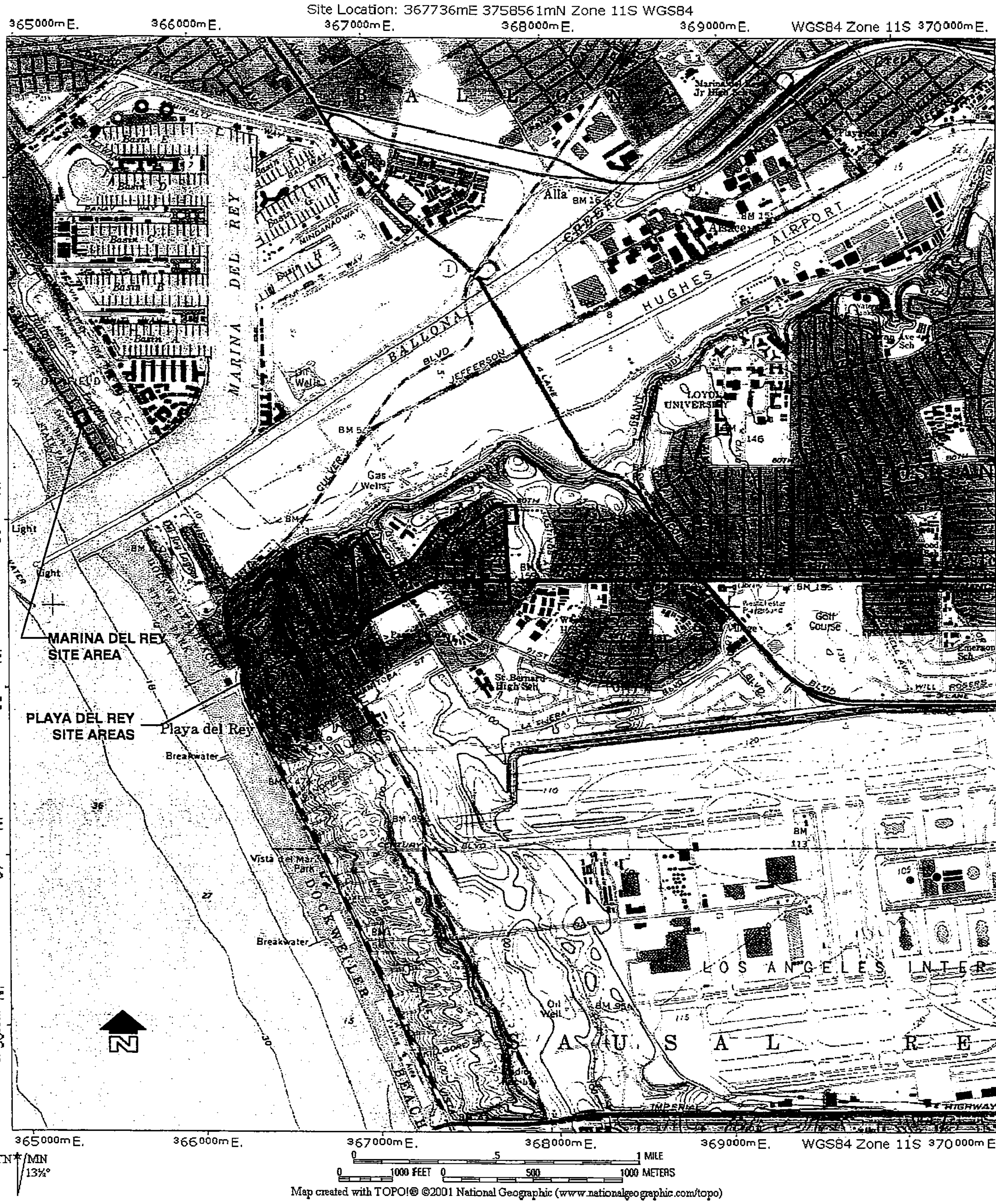
Total Hazard **0.6** **below the State and Federal Safe Level for Lifetime Exposure of 1**

--- - vapor samples were only used to estimate risks for indoor air
* - soil data were only used to evaluate ingestion of soil, dermal contact with soil and inhalation of volatiles and particulates in outdoor air
na - not applicable, chemical not considered a potential human carcinogen

This table presents the results of the risk assessment.



FIGURES



DATE	PROJECT NUMBER
MAR 2004	23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA

SITE LOCATION MAP

PROJECT LOCATION: MARINA DEL REY AND PLAYA DEL REY, CALIFORNIA

FIGURE **1.1.1**

23483 – CPUC\CAD\HealthRisk\23483FIG1 SITE.dwg ESfiles JURE 1.1 | Ref Files : SITETOPO.JPG 7/04 11:10am

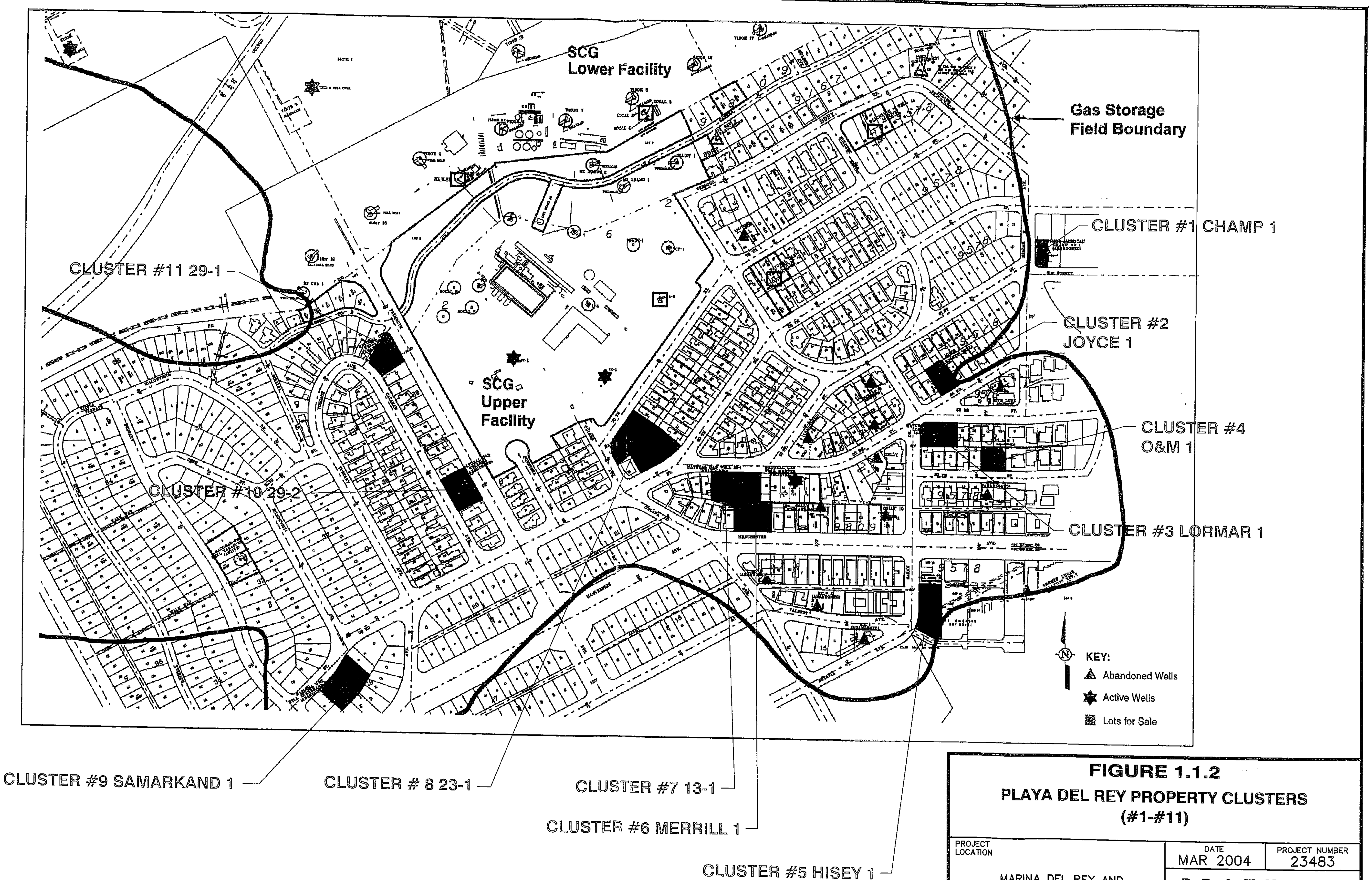


FIGURE 1.1.2

PLAYA DEL REY PROPERTY CLUSTERS (#1-#11)

PROJECT LOCATION	DATE	PROJECT NUMBER
MARINA DEL REY AND PLAYA DEL REY, CALIFORNIA	MAR 2004	23483
	BROWN AND CALDWELL IRVINE, CALIFORNIA	

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17x11 | Ref Files : FIGURE 1-2.jpg

23483 - CPUC\CAD\HealthRisk\23483FIG1-2.dwg

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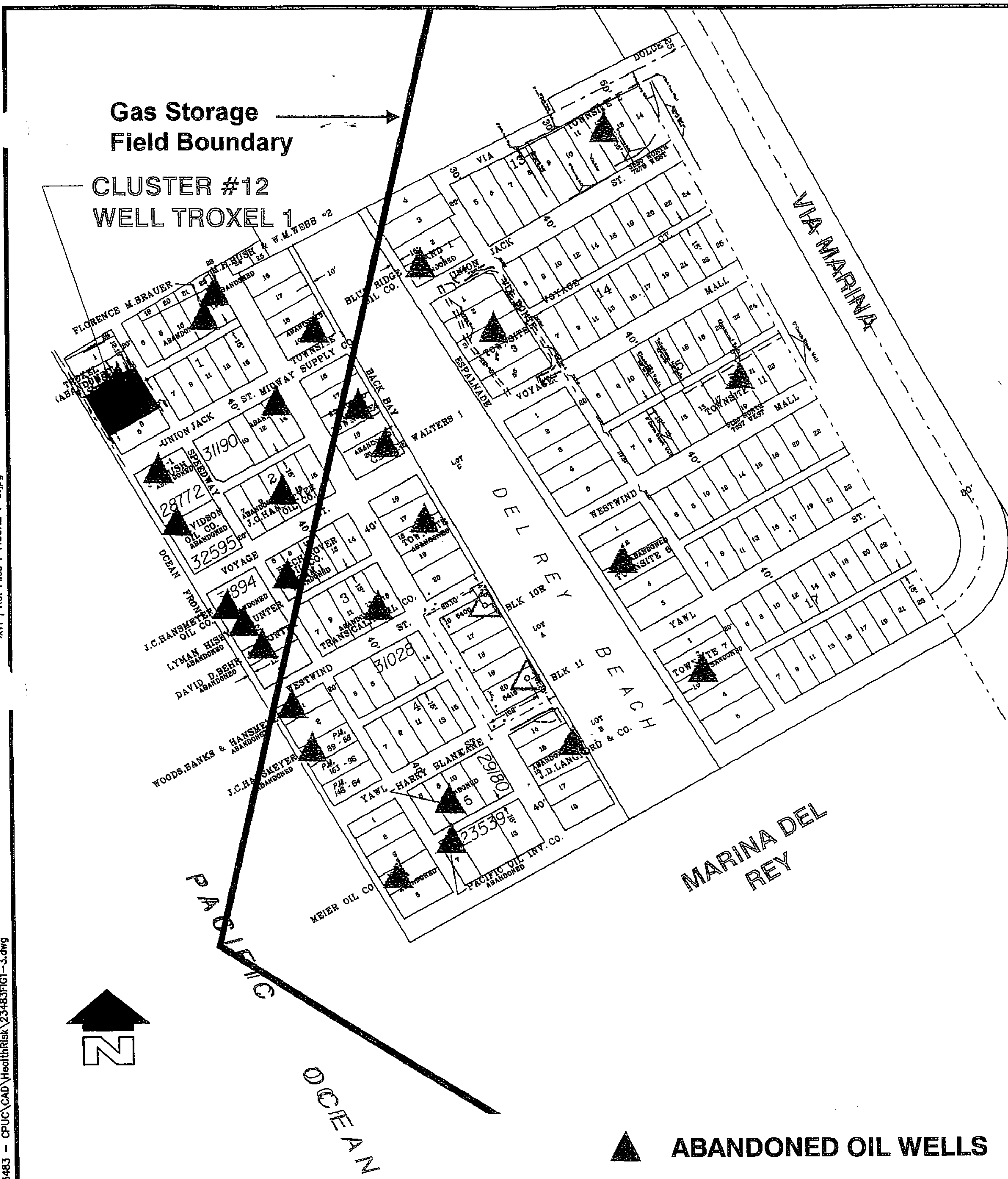


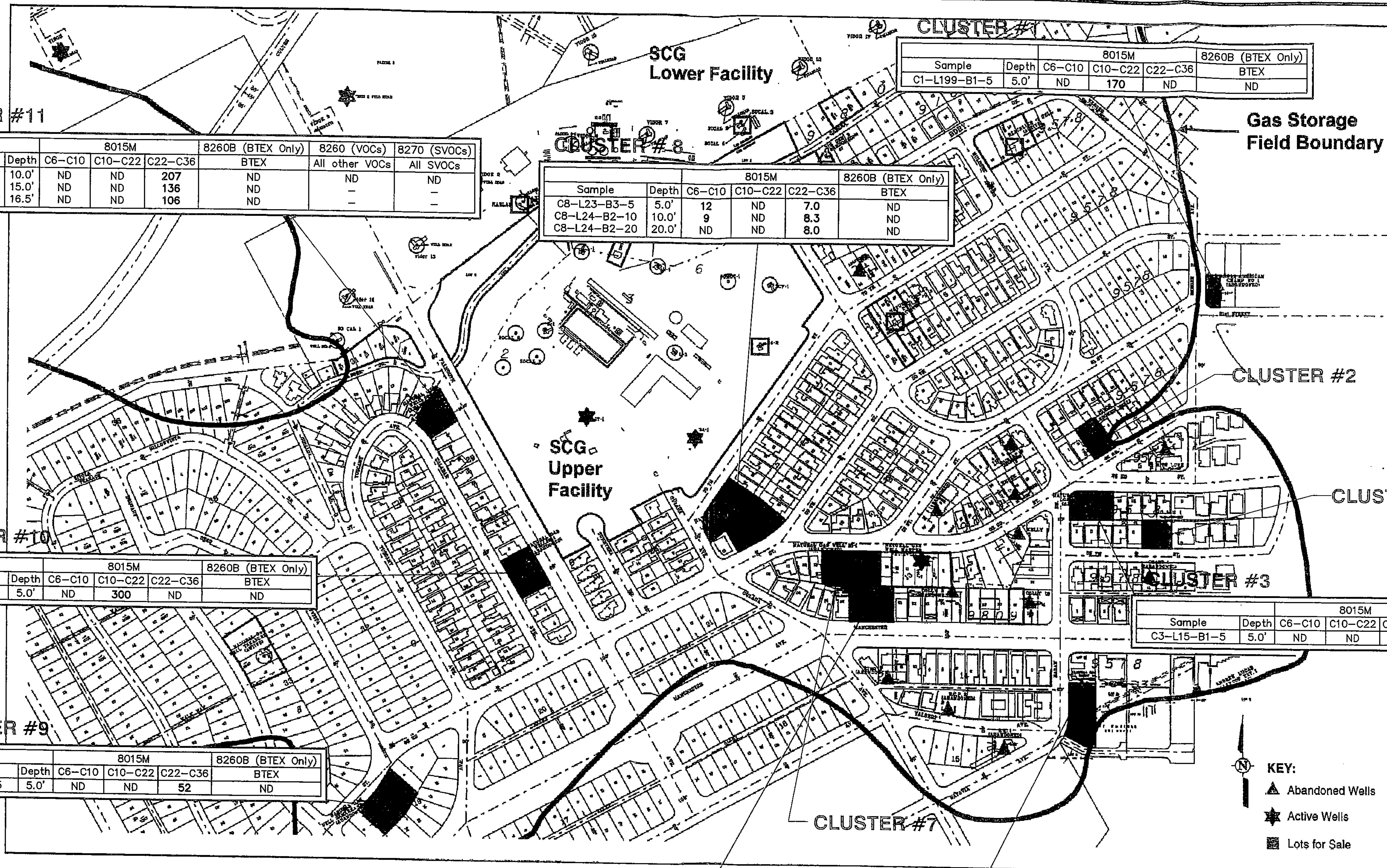
DATE	PROJECT NUMBER
MAR 2004	23483

MARINA DEL REY LOT CLUSTER #12

BROWN AND CALDWELL
IRVINE, CALIFORNIA

PROJECT LOCATION: MARINA DEL REY AND PLAYA DEL REY, CALIFORNIA

FIGURE **1.1.3**



CLUSTER #1

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX
C1–L199–B1–5	5.0'	ND	170	ND	ND

CLUSTER #11

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX	8260 (VOCs) All other VOCs	8270 (SVOCs) All SVOCs
C11–L19–B2–10	10.0'	ND	ND	207	ND	ND	ND
C11–L19–B2–15	15.0'	ND	ND	136	ND	–	–
C11–L19–B2–DUP	16.5'	ND	ND	106	ND	–	–

CLUSTER # 8

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX
C8–L23–B3–5	5.0'	12	ND	7.0	ND
C8–L24–B2–10	10.0'	9	ND	8.3	ND
C8–L24–B2–20	20.0'	ND	ND	8.0	ND

CLUSTER #10

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX
C10–L7–B2–5	5.0'	ND	300	ND	ND

CLUSTER #3

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX
C3–L15–B1–5	5.0'	ND	ND	280	ND

CLUSTER #9

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX
C9–L5–B1–5	5.0'	ND	ND	52	ND

CLUSTER #6

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX
C6–L29–B1–5	5.0'	ND	ND	770	ND

CLUSTER #5

Sample	Depth	8015M C6–C10	8015M C10–C22	8015M C22–C36	8260B (BTEX Only) BTEX
C5–L11–B1–10	10.0'	ND	3.0	10	ND

LEGEND

8015M EPA METHOD 8015M FOR TOTAL PETROLEUM HYDROCARBONS

8260B EPA METHOD 8260B FOR VOLATILE ORGANIC COMPOUNDS

BTEX BENZENE, TOLUENE, ETHYLBENZENE, AND XYLENES

SCG SOUTHERN CALIFORNIA GAS

ND NOT DETECTED AT OR ABOVE DETECTION LIMIT

NOTES:
RESULTS ARE IN PARTS PER MILLION (ppm)

FIGURE 2.1.1

PLAYA DEL REY PROPERTY CLUSTERS (#1-#11) PHASE II SOIL SAMPLE RESULTS (SAMPLES WITH DETECTIONS ONLY)

PROJECT LOCATION	DATE	PROJECT NUMBER
PLAYA DEL REY, CALIFORNIA	MAR 2004	23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA

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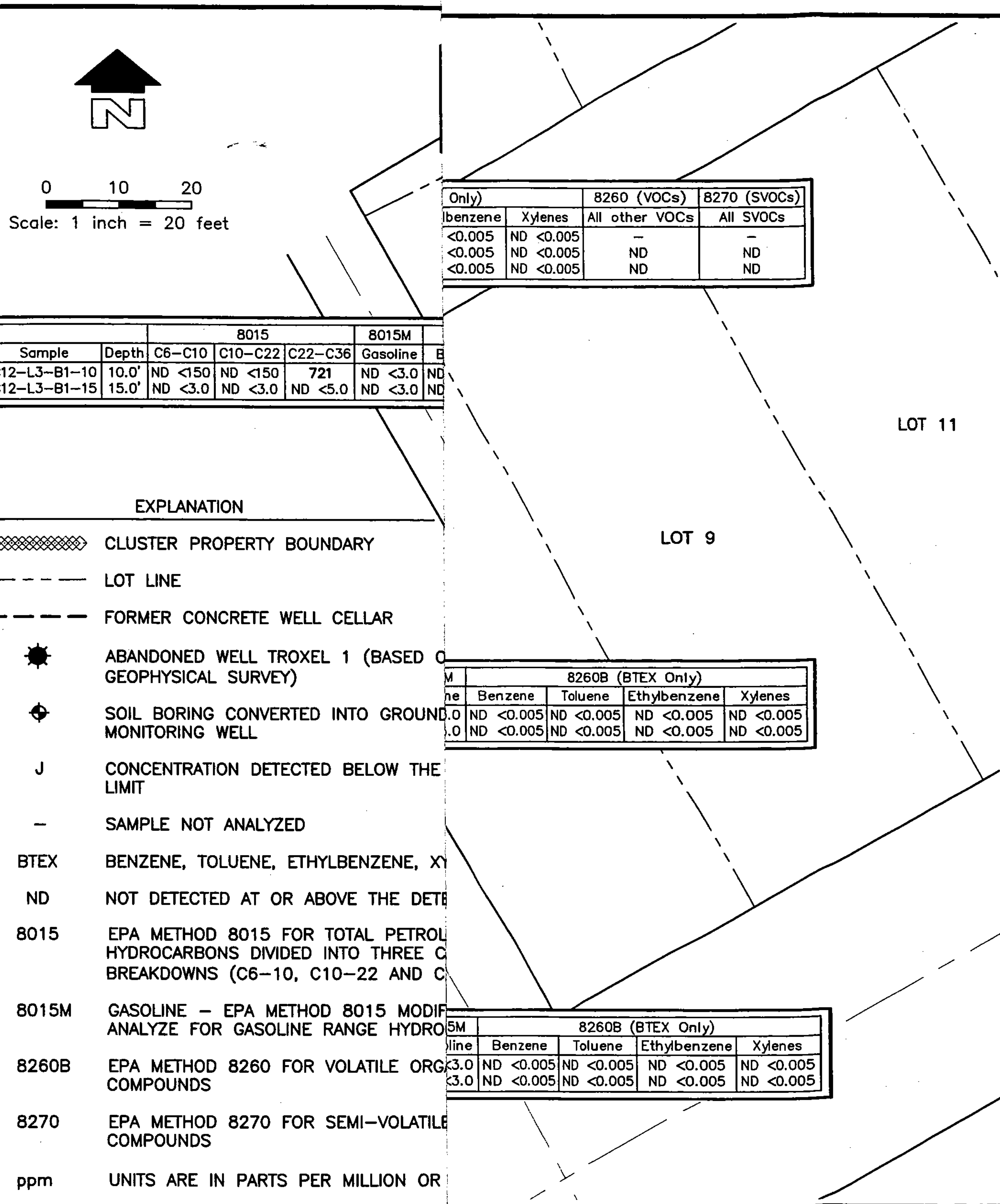
3/17/04 06:49pm



Only)		8260 (VOCs)	8270 (SVOCs)
lbenzene	Xylenes	All other VOCs	All SVOCs
<0.005	ND <0.005	–	–
<0.005	ND <0.005	ND	ND
<0.005	ND <0.005	ND	ND

		8015			8015M	
Sample	Depth	C6–C10	C10–C22	C22–C36	Gasoline	B
C12–L3–B1–10	10.0'	ND <150	ND <150	**721**	ND <3.0	ND
C12–L3–B1–15	15.0'	ND <3.0	ND <3.0	ND <5.0	ND <3.0	ND

M	8260B (BTEX Only)			
ne	Benzene	Toluene	Ethylbenzene	Xylenes
.0	ND <0.005	ND <0.005	ND <0.005	ND <0.005
.0	ND <0.005	ND <0.005	ND <0.005	ND <0.005

5M	8260B (BTEX Only)			
line	Benzene	Toluene	Ethylbenzene	Xylenes
<3.0	ND <0.005	ND <0.005	ND <0.005	ND <0.005
<3.0	ND <0.005	ND <0.005	ND <0.005	ND <0.005

EXPLANATION

◇◇◇◇◇◇	CLUSTER PROPERTY BOUNDARY
— — —	LOT LINE
— — —	FORMER CONCRETE WELL CELLAR
✹	ABANDONED WELL TROXEL 1 (BASED O GEOPHYSICAL SURVEY)
⊕	SOIL BORING CONVERTED INTO GROUND MONITORING WELL
J	CONCENTRATION DETECTED BELOW THE LIMIT
–	SAMPLE NOT ANALYZED
BTEX	BENZENE, TOLUENE, ETHYLBENZENE, XY
ND	NOT DETECTED AT OR ABOVE THE DETE
8015	EPA METHOD 8015 FOR TOTAL PETROL HYDROCARBONS DIVIDED INTO THREE C BREAKDOWNS (C6–10, C10–22 AND C
8015M	GASOLINE – EPA METHOD 8015 MODIF ANALYZE FOR GASOLINE RANGE HYDRO
8260B	EPA METHOD 8260 FOR VOLATILE ORG COMPOUNDS
8270	EPA METHOD 8270 FOR SEMI–VOLATILE COMPOUNDS
ppm	UNITS ARE IN PARTS PER MILLION OR
MG/KG	MILLIGRAMS PER KILOGRAM
BTEX	BENZENE, TOLUENE, ETHYLBENZENE, A
VOCs	VOLATILE ORGANIC COMPOUNDS
SVOCs	SEMIVOLATILE ORGANIC COMPOUNDS

SOURCE:
BASEMAP DERIVED FROM; LOCUS TECHNOLOGIES, LOT
FIGURE A, DRAWING NO. 22–028–A6 AND ENV AMER
FIGURE 5, PROJECT NO. SCG–01–T022

FIGURE 2.1.2
RINA DEL REY PROPERTY CLUSTER (#12)
PHASE II SOIL SAMPLE RESULTS

N CALIFORNIA GAS COMPANY
Y AVENUE AND UNION JACK
YA DEL REY, CALIFORNIA

DATE	PROJECT NUMBER
MAR 2004	23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA

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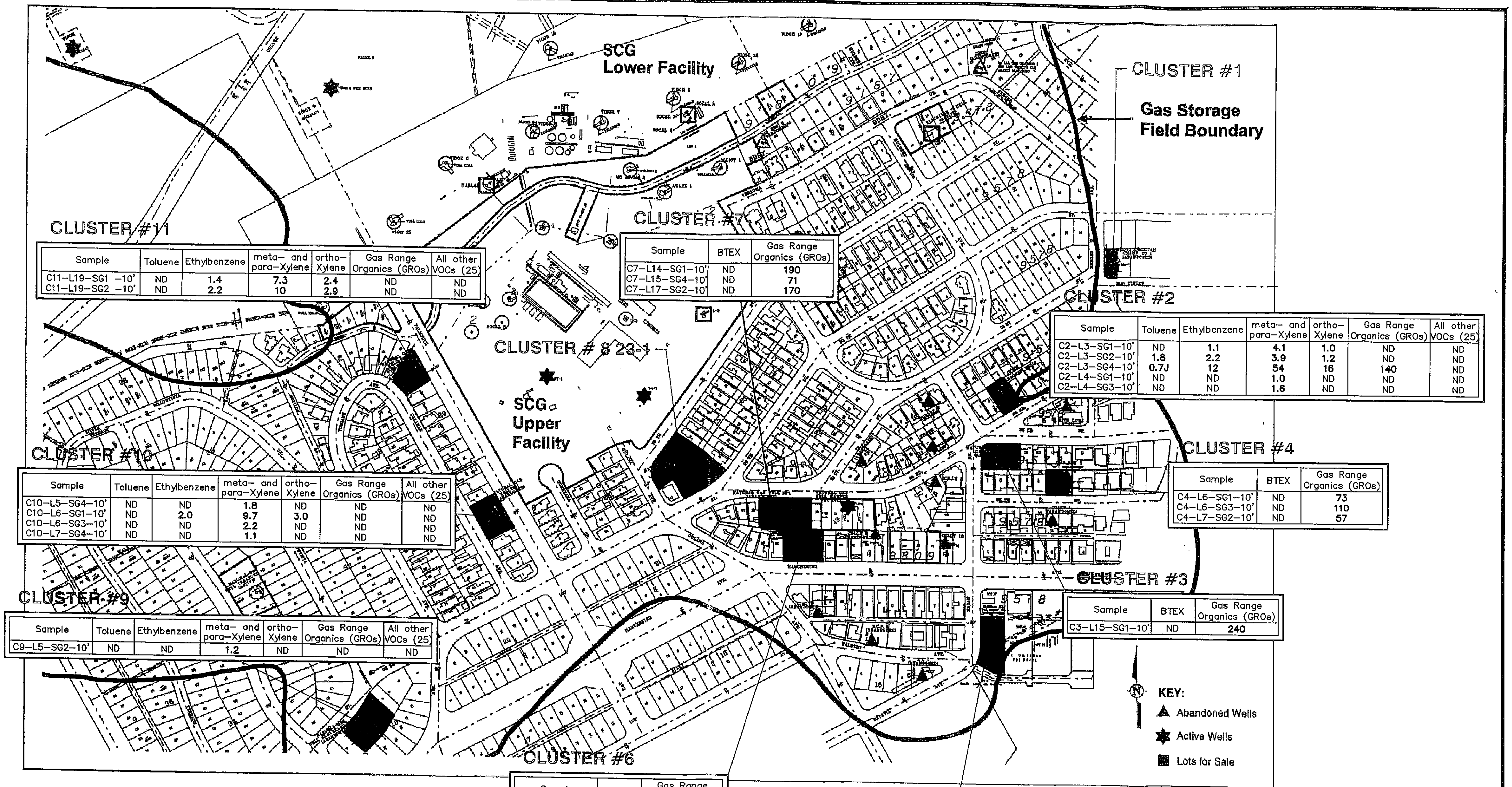


CLUSTER #11

Sample	Toluene	Ethylbenzene	meta- and para-Xylene	ortho-Xylene	Gas Range Organics (GROs)	All other VOCs (25)
C11-L19-SG1 -10'	ND	1.4	7.3	2.4	ND	ND
C11-L19-SG2 -10'	ND	2.2	10	2.9	ND	ND

CLUSTER #7

Sample	BTEX	Gas Range Organics (GROs)
C7-L14-SG1-10'	ND	190
C7-L15-SG4-10'	ND	71
C7-L17-SG2-10'	ND	170

CLUSTER #2

Sample	Toluene	Ethylbenzene	meta- and para-Xylene	ortho-Xylene	Gas Range Organics (GROs)	All other VOCs (25)
C2-L3-SG1-10'	ND	1.1	4.1	1.0	ND	ND
C2-L3-SG2-10'	1.8	2.2	3.9	1.2	ND	ND
C2-L3-SG4-10'	0.7J	12	54	16	140	ND
C2-L4-SG1-10'	ND	ND	1.0	ND	ND	ND
C2-L4-SG3-10'	ND	ND	1.6	ND	ND	ND

CLUSTER #10

Sample	Toluene	Ethylbenzene	meta- and para-Xylene	ortho-Xylene	Gas Range Organics (GROs)	All other VOCs (25)
C10-L5-SG4-10'	ND	ND	1.8	ND	ND	ND
C10-L6-SG1-10'	ND	2.0	9.7	3.0	ND	ND
C10-L6-SG3-10'	ND	ND	2.2	ND	ND	ND
C10-L7-SG4-10'	ND	ND	1.1	ND	ND	ND

CLUSTER #4

Sample	BTEX	Gas Range Organics (GROs)
C4-L6-SG1-10'	ND	73
C4-L6-SG3-10'	ND	110
C4-L7-SG2-10'	ND	57

CLUSTER #3

Sample	BTEX	Gas Range Organics (GROs)
C3-L15-SG1-10'	ND	240

CLUSTER #9

Sample	Toluene	Ethylbenzene	meta- and para-Xylene	ortho-Xylene	Gas Range Organics (GROs)	All other VOCs (25)
C9-L5-SG2-10'	ND	ND	1.2	ND	ND	ND

CLUSTER #6

Sample	BTEX	Gas Range Organics (GROs)
C6-L28-SG1-5'	ND	51

LEGEND

BTEX BENZENE, TOLUENE, ETHYLBENZENE, AND TOTAL XYLENES

ND NOT DETECTED ABOVE DETECTION LIMIT

SCG SOUTHERN CALIFORNIA GAS

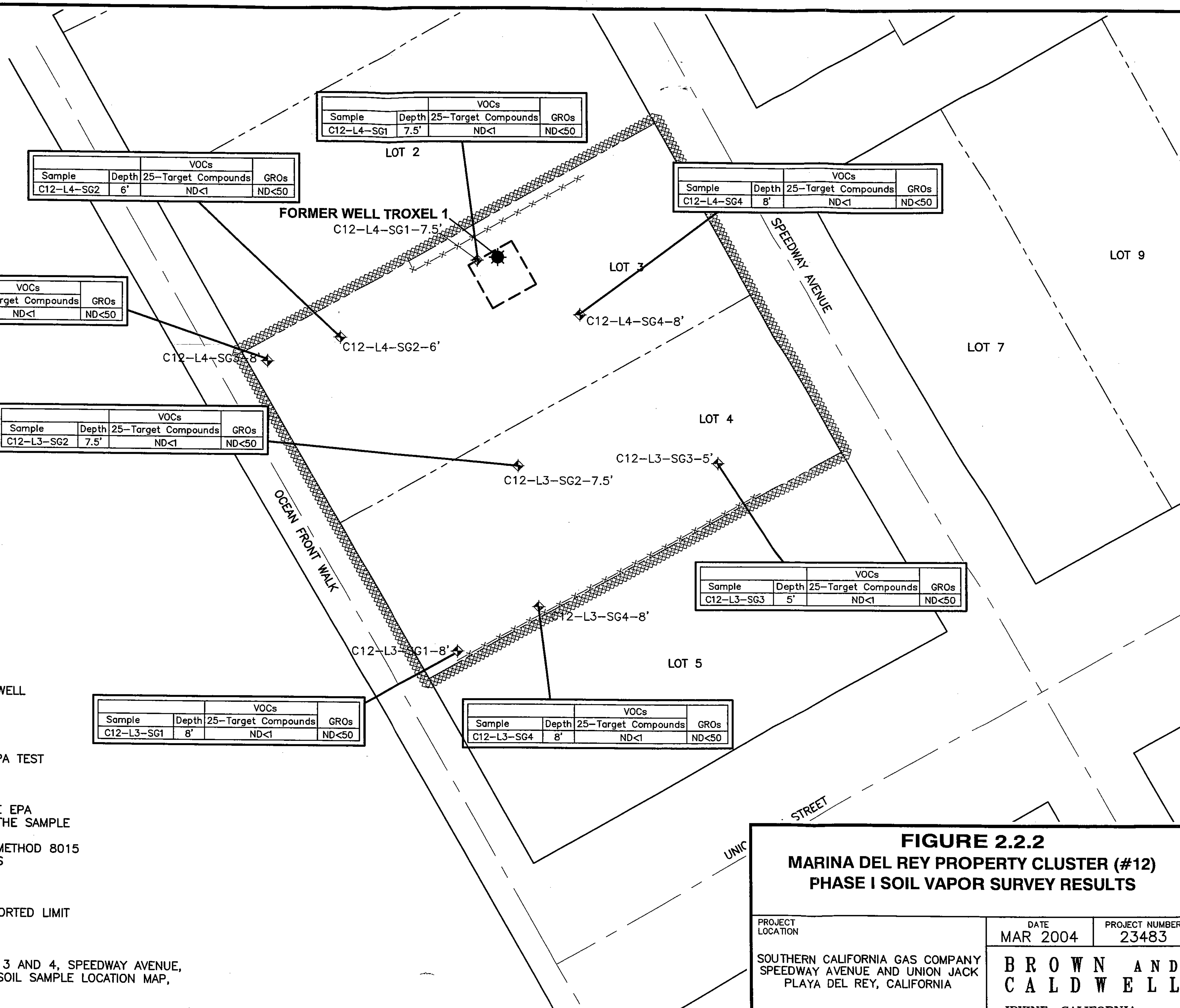
VOCs VOLATILE ORGANIC COMPOUNDS

NOTE:
RESULTS ARE IN PARTS PER BILLION VOLUME (ppbV)

FIGURE 2.2.1
PLAYA DEL REY PROPERTY CLUSTERS (#1-#11) PHASE I SOIL VAPOR SURVEY RESULTS (SAMPLES WITH DETECTIONS ONLY)

PROJECT LOCATION	DATE	PROJECT NUMBER
PLAYA DEL REY, CALIFORNIA	MAR 2004	23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA



Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L4-SG1	7.5'	ND<1	ND<50

Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L4-SG2	6'	ND<1	ND<50

Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L4-SG4	8'	ND<1	ND<50

Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L4-SG3	8'	ND<1	ND<50

Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L3-SG2	7.5'	ND<1	ND<50

Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L3-SG3	5'	ND<1	ND<50

Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L3-SG1	8'	ND<1	ND<50

Sample	Depth	VOCs 25-Target Compounds	GROs
C12-L3-SG4	8'	ND<1	ND<50

EXPLANATION

CLUSTER PROPERTY BOUNDARY

LOT LINE

FORMER CONCRETE WELL CELLAR

APPROXIMATE LOCATION OF ABANDONED WELL TROXEL 1

SOIL GAS SURVEY SAMPLE LOCATIONS

VOCs — VOLATILE ORGANIC COMPOUNDS USING EPA TEST METHOD 8260 MODIFIED FOR SOIL GAS

25-TARGET COMPOUNDS — A LIST OF 25 SELECTED VOCs FROM THE EPA METHOD 8260 LIST WAS ANALYZED FOR THE SAMPLE

GROs — GAS RANGE ORGANICS USING EPA TEST METHOD 8015 MODIFIED FOR GASOLINE RANGE ORGANICS

ppbV — PARTS PER BILLION VOLUME

ND<1 — ANALYTE NON DETECTED ABOVE THE REPORTED LIMIT OF QUANTITATION

SOURCE:
BASEMAP DERIVED FROM; LOCUS TECHNOLOGIES, LOT NO. 3 AND 4, SPEEDWAY AVENUE, FIGURE A, DRAWING NO. 22-028-A6 AND ENV AMERICA, SOIL SAMPLE LOCATION MAP, FIGURE 5, PROJECT NO. SCG-01-T022

FIGURE 2.2.2

MARINA DEL REY PROPERTY CLUSTER (#12) PHASE I SOIL VAPOR SURVEY RESULTS

PROJECT LOCATION: SOUTHERN CALIFORNIA GAS COMPANY, SPEEDWAY AVENUE AND UNION JACK, PLAYA DEL REY, CALIFORNIA

DATE: MAR 2004

PROJECT NUMBER: 23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA

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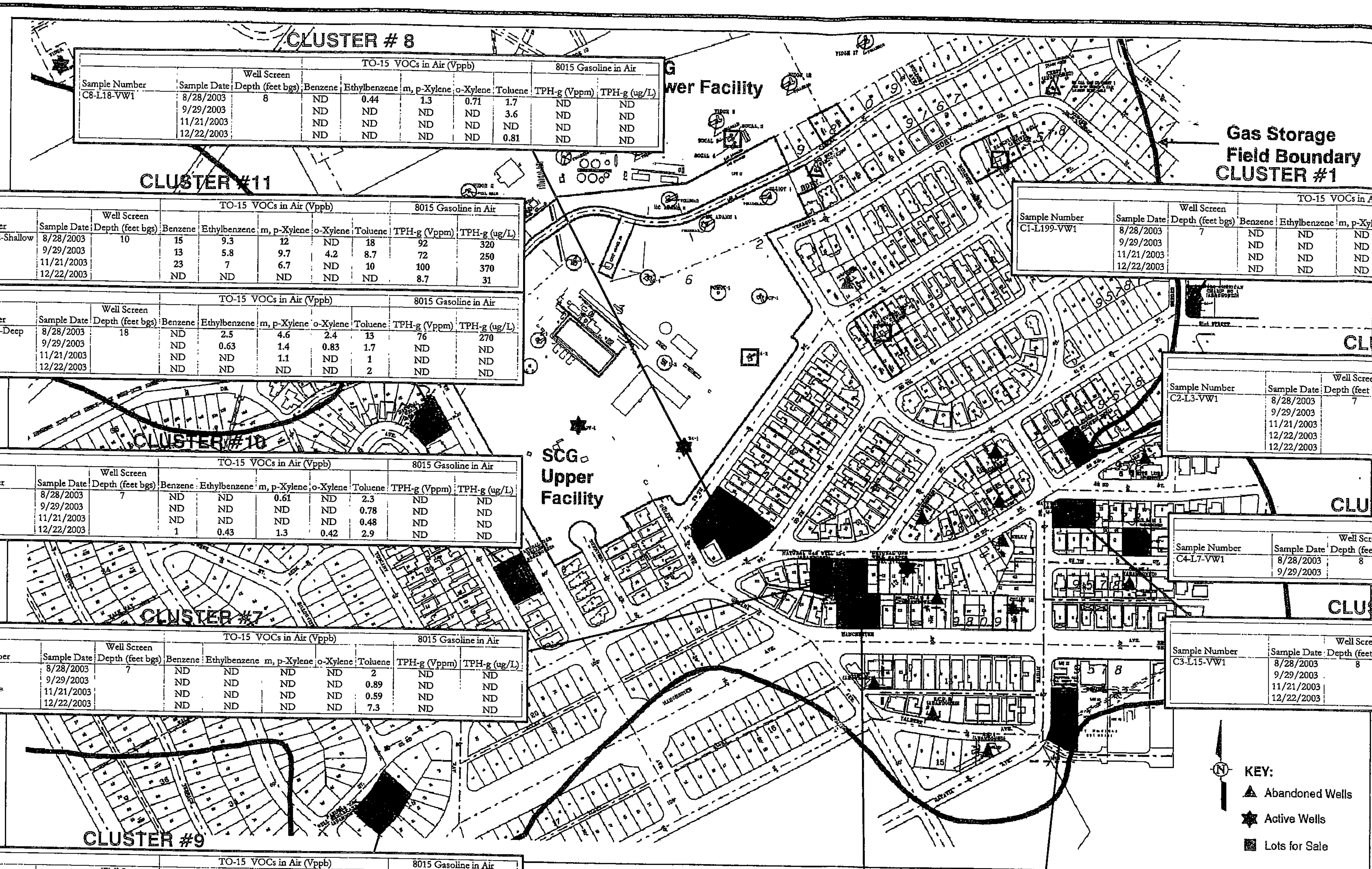

CLUSTER # 8

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C8-L18-VW1	8/28/2003	8	ND	0.44	1.3	0.71	1.7	ND	ND
	9/29/2003		ND	ND	ND	ND	3.6	ND	ND
	11/21/2003		ND	ND	ND	ND	ND	ND	ND
	12/22/2003		ND	ND	ND	ND	0.81	ND	ND

CLUSTER #11

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C11-L19-VW2-Shallow	8/28/2003	10	15	9.3	12	ND	18	92	320
	9/29/2003		13	5.8	9.7	4.2	8.7	72	250
	11/21/2003		23	7	6.7	ND	10	100	370
	12/22/2003		ND	ND	ND	ND	ND	8.7	31

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C11-L19-VW2-Deep	8/28/2003	18	ND	2.5	4.6	2.4	13	76	270
	9/29/2003		ND	0.63	1.4	0.83	1.7	ND	ND
	11/21/2003		ND	ND	1.1	ND	1	ND	ND
	12/22/2003		ND	ND	ND	ND	2	ND	ND

CLUSTER #1

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C1-L199-VW1	8/28/2003	7	ND	ND	ND	ND	2.6	ND	ND
	9/29/2003		ND	ND	ND	ND	1.2	ND	ND
	11/21/2003		ND	ND	ND	ND	0.61	ND	ND
	12/22/2003		ND	ND	ND	ND	ND	8.2	ND

CLUSTER #2

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C2-L3-VW1	8/28/2003	7	ND	ND	ND	ND	ND	53	190
	9/29/2003		ND	ND	ND	ND	1.9	ND	ND
	11/21/2003		ND	ND	ND	ND	0.61	ND	ND
	12/22/2003		ND	ND	ND	ND	1.2	ND	ND
	12/22/2003		0.59	0.42	1.1	0.39	9.3	ND	ND

CLUSTER #10

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C10-L6-VW1	8/28/2003	7	ND	ND	0.61	ND	2.3	ND	ND
	9/29/2003		ND	ND	ND	ND	0.78	ND	ND
	11/21/2003		ND	ND	ND	ND	0.48	ND	ND
	12/22/2003		1	0.43	1.3	0.42	2.9	ND	ND

CLUSTER #4

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C4-L7-VW1	8/28/2003	8	ND	0.71	1.2	0.88	5.2	ND	ND
	9/29/2003		ND	ND	0.44	0.39	1.5	ND	ND

CLUSTER #7

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C7-L16-VW2	8/28/2003	7	ND	ND	ND	ND	2	ND	ND
	9/29/2003		ND	ND	ND	ND	0.89	ND	ND
C7-L16-VW1*	11/21/2003		ND	ND	ND	ND	0.59	ND	ND
	12/22/2003		ND	ND	ND	ND	7.3	ND	ND

CLUSTER #3

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C3-L15-VW1	8/28/2003	8	ND	0.63	1.2	0.58	5.2	ND	ND
	9/29/2003		ND	0.38	0.71	0.34	2.5	ND	ND
	11/21/2003		ND	ND	0.54	ND	1	ND	ND
	12/22/2003		ND	0.53	2	0.72	3.1	ND	ND

CLUSTER #9

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C9-L5-VW1	8/28/2003	8	ND	ND	0.41	ND	3	ND	ND
	9/29/2003		ND	ND	0.54	ND	1.3	ND	ND
	11/21/2003		ND	ND	ND	ND	0.58	ND	ND
	12/22/2003		ND	ND	ND	ND	1.1	ND	ND

CLUSTER #6

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C6-L29-VW1	8/28/2003	10	ND	ND	0.73	ND	2.3	ND	ND
	9/29/2003		ND	0.61	2.2	ND	1.1	ND	ND

CLUSTER #5

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs in Air (Vppb) Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	8015 Gasoline in Air TPH-g (Vppm)	TPH-g (ug/L)
C5-L11-VW1	8/28/2003	7	ND	0.77	1.1	0.55	4.6	ND	ND
	9/29/2003		ND	0.43	0.78	0.42	2.1	ND	ND

LEGEND

BTEX BENZENE, TOLUENE, ETHYLBENZENE, AND TOTAL XYLENES
bgs BELOW GROUND SURFACE
TPH-g TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
TO-15 VOCs IN AIR
EPA METHOD TO-15 FOR VOLATILE ORGANIC COMPOUNDS IN AIR
8015 GASOLINE IN AIR
EPA METHOD 8015 FOR TOTAL PETROLEUM HYDROCARBONS AS GASOLINE IN AIR

NOTE:
RESULTS ARE IN PARTS PER BILLION VOLUME (Vppb), PARTS PER MILLION VOLUME (Vppm), OR MICROGRAMS PER LITER (μg/L)

* C7-L16-VW1-VW2 WERE COLLECTED FROM THE SAME POINT AND MISLABELED

FIGURE 2.2.3

PLAYA DEL REY PROPERTY CLUSTERS (#1-#11)
PHASE II OF SOIL GAS MONITORING RESULTS WELLS
(DETECTIONS ONLY)

PROJECT LOCATION: PLAYA DEL REY, CALIFORNIA

DATE: MAR 2004

PROJECT NUMBER: 23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA

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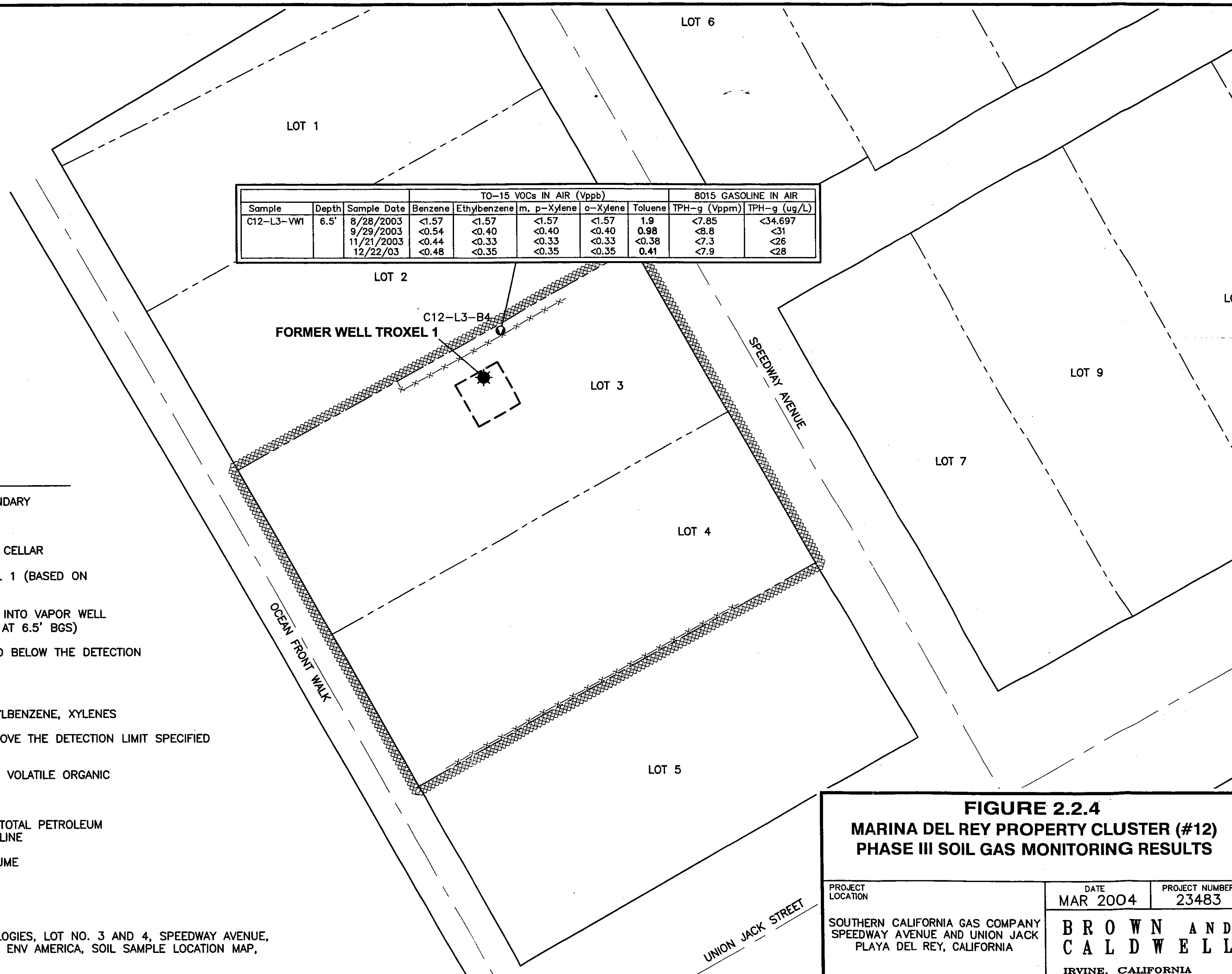
EStiles



			TO-15 VOCs IN AIR (Vppb)					8015 GASOLINE IN AIR	
Sample	Depth	Sample Date	Benzene	Ethylbenzene	m, p-Xylene	o-Xylene	Toluene	TPH-g (Vppm)	TPH-g (ug/L)
C12-L3-VW1	6.5'	8/28/2003	<1.57	<1.57	<1.57	<1.57	**1.9**	<7.85	<34.697
		9/29/2003	<0.54	<0.40	<0.40	<0.40	**0.98**	<8.8	<31
		11/21/2003	<0.44	<0.33	<0.33	<0.33	<0.38	<7.3	<26
		12/22/03	<0.48	<0.35	<0.35	<0.35	**0.41**	<7.9	<28

EXPLANATION

- CLUSTER PROPERTY BOUNDARY
- LOT LINE
- FORMER CONCRETE WELL CELLAR
- ABANDONED WELL TROXEL 1 (BASED ON GEOPHYSICAL SURVEY)
- SOIL BORING CONVERTED INTO VAPOR WELL C12-L3-VW-1 (IMPLANT AT 6.5' BGS)
- J — CONCENTRATION DETECTED BELOW THE DETECTION LIMIT
- \- — SAMPLE NOT ANALYZED
- BTEX — BENZENE, TOLUENE, ETHYLBENZENE, XYLENES
- <1.57 — NOT DETECTED AT OR ABOVE THE DETECTION LIMIT SPECIFIED
- TO-15 VOCs IN AIR — EPA METHOD TO-15 FOR VOLATILE ORGANIC COMPOUNDS IN AIR
- 8015 GASOLINE IN AIR — EPA METHOD 8015 FOR TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
- Vppm — PARTS PER MILLION VOLUME
- μg/L — MICROGRAMS PER LITER

SOURCE:
BASEMAP DERIVED FROM; LOCUS TECHNOLOGIES, LOT NO. 3 AND 4, SPEEDWAY AVENUE, FIGURE A, DRAWING NO. 22-028-A6 AND ENV AMERICA, SOIL SAMPLE LOCATION MAP, FIGURE 5, PROJECT NO. SCG-01-T022

FIGURE 2.2.4
MARINA DEL REY PROPERTY CLUSTER (#12) PHASE III SOIL GAS MONITORING RESULTS

PROJECT LOCATION
SOUTHERN CALIFORNIA GAS COMPANY
SPEEDWAY AVENUE AND UNION JACK
PLAYA DEL REY, CALIFORNIA

DATE: MAR 2004
PROJECT NUMBER: 23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA

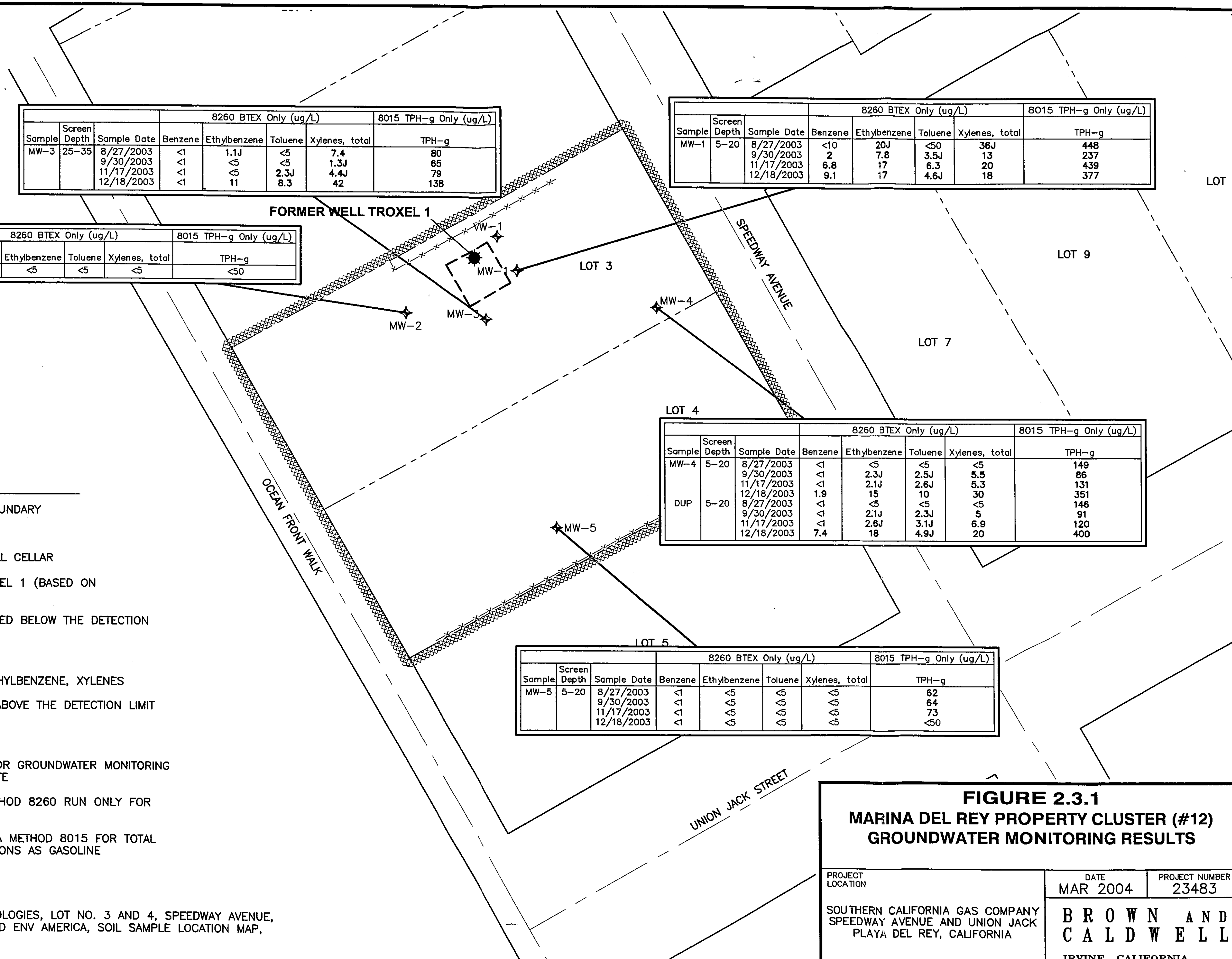
3/17/04 05:58pm
17x11 | Ref Files : BASE.dwg
23483 - CPUC\CAD\HealthRisk\Troxel-SUMMA.dwg
EStiles

3/17/04 05:54pm

17x11 | Ref Files : BASE.dwg

23483 - CPUC\CAD\HealthRisk\Troxel-GW.dwg

EStiles



Sample	Screen Depth	Sample Date	8260 BTEX Only (ug/L) Benzene	Ethylbenzene	Toluene	Xylenes, total	8015 TPH-g Only (ug/L) TPH-g
MW-3	25-35	8/27/2003	<1	1.1J	<5	7.4	80
		9/30/2003	<1	<5	<5	1.3J	65
		11/17/2003	<1	<5	2.3J	4.4J	79
		12/18/2003	<1	11	8.3	42	138

Sample	Screen Depth	Sample Date	8260 BTEX Only (ug/L) Benzene	Ethylbenzene	Toluene	Xylenes, total	8015 TPH-g Only (ug/L) TPH-g
MW-1	5-20	8/27/2003	<10	20J	<50	36J	448
		9/30/2003	2	7.8	3.5J	13	237
		11/17/2003	6.8	17	6.3	20	439
		12/18/2003	9.1	17	4.6J	18	377

Sample	Screen Depth	Sample Date	8260 BTEX Only (ug/L) Benzene	Ethylbenzene	Toluene	Xylenes, total	8015 TPH-g Only (ug/L) TPH-g
MW-2	5-20	8/27/2003	<1	<5	<5	<5	<50

Sample	Screen Depth	Sample Date	8260 BTEX Only (ug/L) Benzene	Ethylbenzene	Toluene	Xylenes, total	8015 TPH-g Only (ug/L) TPH-g
MW-4	5-20	8/27/2003	<1	<5	<5	<5	149
		9/30/2003	<1	2.3J	2.5J	5.5	86
		11/17/2003	<1	2.1J	2.6J	5.3	131
		12/18/2003	1.9	15	10	30	351
DUP	5-20	8/27/2003	<1	<5	<5	<5	146
		9/30/2003	<1	2.1J	2.3J	5	91
		11/17/2003	<1	2.6J	3.1J	6.9	120
		12/18/2003	7.4	18	4.9J	20	400

Sample	Screen Depth	Sample Date	8260 BTEX Only (ug/L) Benzene	Ethylbenzene	Toluene	Xylenes, total	8015 TPH-g Only (ug/L) TPH-g
MW-5	5-20	8/27/2003	<1	<5	<5	<5	62
		9/30/2003	<1	<5	<5	<5	64
		11/17/2003	<1	<5	<5	<5	73
		12/18/2003	<1	<5	<5	<5	<50

EXPLANATION

(hatched line)	CLUSTER PROPERTY BOUNDARY
– – – –	LOT LINE
— — — —	FORMER CONCRETE WELL CELLAR
(symbol)	ABANDONED WELL TROXEL 1 (BASED ON GEOPHYSICAL SURVEY)
J	CONCENTRATION DETECTED BELOW THE DETECTION LIMIT
–	SAMPLE NOT ANALYZED
BTEX	BENZENE, TOLUENE, ETHYLBENZENE, XYLENES
<1	NOT DETECTED AT OR ABOVE THE DETECTION LIMIT SPECIFIED
DUP	DUPLICATE SAMPLE
SCREEN DEPTH	SCREENING INTERVAL FOR GROUNDWATER MONITORING WELL INSTALLED ON-SITE
8260	BTEX ONLY – EPA METHOD 8260 RUN ONLY FOR BTEX
8015	GASOLINE IN AIR – EPA METHOD 8015 FOR TOTAL PETROLEUM HYDROCARBONS AS GASOLINE
μg/L	MICROGRAMS PER LITER

SOURCE:
BASEMAP DERIVED FROM; LOCUS TECHNOLOGIES, LOT NO. 3 AND 4, SPEEDWAY AVENUE, FIGURE A, DRAWING NO. 22-028-A6 AND ENV AMERICA, SOIL SAMPLE LOCATION MAP, FIGURE 5, PROJECT NO. SCG-01-T022

FIGURE 2.3.1
MARINA DEL REY PROPERTY CLUSTER (#12) GROUNDWATER MONITORING RESULTS

PROJECT LOCATION
SOUTHERN CALIFORNIA GAS COMPANY
SPEEDWAY AVENUE AND UNION JACK
PLAYA DEL REY, CALIFORNIA

DATE: MAR 2004

PROJECT NUMBER: 23483

BROWN AND CALDWELL
IRVINE, CALIFORNIA

APPENDIX A

LABORATORY DATA

1. Soil Samples Collected from Surface to 15 foot Depth at All Clusters
2. Soil Samples Collected from All Depths at All Clusters
3. Vapor Samples Collected from Temporary Sampling Points
4. Vapor Samples Collected from Permanent Vapor Monitoring Wells
5. Groundwater Samples Collected from Cluster 12

Table 1
Soil Samples Collected from Surface to 15 feet depth at All Clusters

Sample ID	Sample Date	Depth (feet)	8015 (Carbon Chain Identification) C6-C10 ppm	C10-C22 ppm	C22-C36 ppm	8260B (BTEX Only) Benzene ppm	Toluene ppm	Ethylbenzene ppm	Xylenes ppm	8015M Gasoline ppm	8260 All VOCs	8270 All SVOCs
C1-L199-B1-5	07/10/03	5.0	<3.0	**170**	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L15-B1-5	07/09/03	5.0	<3.0	<3.0	**280**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L29-B1-5	07/15/03	5.0	<300	<300	**770**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L23-B1-5	07/15/03	5.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L23-B3-5	07/15/03	5.0	**12**	<3.0	**7.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L5-B1-5	07/10/03	5.0	<15	<15	**52**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L7-B2-5	07/14/03	5.0	<30	**300**	<50	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B2-5	07/21/03	5.0	<3.0	<3.0	**5.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L4-B3-5	07/22/03	5.0	<60	<60	**130**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B6-5	07/22/03	5.0	<150	<150	**470**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L29-B3-8.5	7/16/2003	8.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B4-8.5	07/16/03	8.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L14-B5-8.5	07/16/03	8.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L16-B2-10	07/09/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L14-B3-10	07/09/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C4-L6-B2-10	07/09/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C5-L11-B1-10	07/10/03	10.0	<3.0	**3.0**	**10**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L28-B2-10	07/15/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L16-B2-10	07/14/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L24-B2-10	07/15/03	10.0	**9**	<3.0	**8.3**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L19-B4-10	07/15/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L20-B6-10	07/15/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L7-B3-10	07/10/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L6-B1-10	07/14/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L5-B3-10	07/14/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B1-10	07/11/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B2-10	07/11/03	10.0	<60	<60	**207**	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C12-L3-B1-10	07/21/03	10.0	<150	<150	**721**	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C12-L3-B2-10	07/21/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C12-L4-B3-10	07/22/03	10.0	<3.0	<3.0	**9.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L28-B2-DUP	07/15/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L19-B4-DUP	07/15/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--

Table 1
Soil Samples Collected from Surface to 15 feet depth at All Clusters

Sample ID	Sample Date	Depth (feet)	8015 (Carbon Chain Identification) C6-C10 ppm	C10-C22 ppm	C22-C36 ppm	8260B (BTEX Only) Benzene ppm	Toluene ppm	Ethylbenzene ppm	Xylenes ppm	8015M Gasoline ppm	8260 All VOCs	8270 All SVOCs
C10-L5-B3-DUP	07/14/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B2-DUP	07/21/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C7-L15-B3-13.5	07/16/03	13.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L8-B4-13.5	07/16/03	13.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L3-B1-15	07/11/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L3-B3-15	07/11/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C4-L7-B1-15	07/09/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B1-15	07/14/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B3-DUP	07/16/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L23-B1-15	07/15/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L18-B5-15	07/15/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L6-B2-15	07/10/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L8-B4-DUP	07/16/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B2-15	07/11/03	15.0	<30	<30	**136**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B1-15	07/21/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B6-15	07/22/03	15.0	**9.0**	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
Data Summary												
Minimum			9	3	5	0	0	0	0	0	0	0
Maximum			12	300	770	0	0	0	0	0	0	0
Depth of Max			5	5	5	NA	NA	NA	NA	NA	NA	NA
Number of Samples			48	48	48	48	48	48	48	48	4	4
Number of Positive Detections			3	3	13	0	0	0	0	0	0	0

ppm = parts per million
-- = Sample not analyzed
ND = Not detected

Table 2
Soil Samples Collected from All Depths at All Clusters

Sample ID	Sample Date	Depth (feet)	8015 (Carbon Chain Identification) C6-C10 ppm	C10-C22 ppm	C22-C36 ppm	8260B (BTEX Only) Benzene ppm	Toluene ppm	Ethylbenzene ppm	Xylenes ppm	8015M Gasoline ppm	8260 All VOCs	8270 All SVOCs
C1-L199-B1-5	07/10/03	5.0	<3.0	**170**	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C1-L199-B1-30	07/10/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L3-B1-15	07/11/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L3-B1-30	07/11/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L4-B2-20	07/11/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L3-B3-DUP	07/11/03	16.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L3-B3-15	07/11/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C2-L3-B3-20	07/11/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L15-B1-5	07/09/03	5.0	<3.0	<3.0	**280**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L15-B1-20	07/09/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L16-B2-10	07/09/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L16-B2-20	07/09/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L14-B3-10	07/09/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C3-L14-B3-20	07/09/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C4-L7-B1-15	07/09/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C4-L7-B1-30	07/09/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C4-L6-B2-10	07/09/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C4-L6-B2-20	07/09/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C5-L11-B1-10	07/10/03	10.0	<3.0	**3.0**	**10**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L29-B1-5	07/15/03	5.0	<300	<300	**770**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L29-B1-30	07/15/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L28-B2-10	07/15/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L28-B2-DUP	07/15/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L28-B2-20	07/15/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L29-B3-8.5	7/16/2003	8.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C6-L29-B3-18.5	7/16/2003	18.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B1-15	07/14/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B1-20	07/14/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L16-B2-10	07/14/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L16-B2-30	07/14/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B3-13.5	07/16/03	13.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B3-DUP	07/16/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--

Table 2
Soil Samples Collected from All Depths at All Clusters

Sample ID	Sample Date	Depth (feet)	8015 (Carbon Chain Identification) C6-C10 ppm	C10-C22 ppm	C22-C36 ppm	8260B (BTEX Only) Benzene ppm	Toluene ppm	Ethylbenzene ppm	Xylenes ppm	8015M Gasoline ppm	8260 All VOCs	8270 All SVOCs
C7-L15-B3-18.5	07/16/03	18.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B4-8.5	07/16/03	8.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L15-B4-18.5	07/16/03	18.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C7-L14-B5-8.5	07/16/03	8.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L23-B1-5	07/15/03	5.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L23-B1-15	07/15/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L24-B2-10	07/15/03	10.0	**9**	<3.0	**8.3**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L24-B2-20	07/15/03	20.0	<3.0	<3.0	**8.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L23-B3-5	07/15/03	5.0	**12**	<3.0	**7.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L23-B3-20	07/15/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L18-B5-15	07/15/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L18-B5-30	07/15/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L19-B4-DUP	07/15/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L19-B4-10	07/15/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L19-B4-20	07/15/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L20-B6-10	07/15/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C8-L20-B6-20	07/15/03	20	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L5-B1-5	07/10/03	5.0	<15	<15	**52**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L5-B1-30	07/10/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L6-B2-15	07/10/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L6-B2-20	07/10/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L7-B3-10	07/10/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L7-B3-30	07/10/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L8-B4-13.5	07/16/03	13.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L8-B4-DUP	07/16/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C9-L8-B4-18.5	07/16/03	18.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L6-B1-10	07/14/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L6-B1-30	07/14/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L7-B2-5	07/14/03	5.0	<30	**300**	<50	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L7-B2-20	07/14/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L5-B3-10	07/14/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L5-B3-DUP	07/14/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--

Table 2
Soil Samples Collected from All Depths at All Clusters

Sample ID	Sample Date	Depth (feet)	8015 (Carbon Chain Identification) C6-C10 ppm	C10-C22 ppm	C22-C36 ppm	8260B (BTEX Only) Benzene ppm	Toluene ppm	Ethylbenzene ppm	Xylenes ppm	8015M Gasoline ppm	8260 All VOCs	8270 All SVOCs
C10-L5-B3-20	07/14/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L6-B4-20	07/21/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L6-B4-30	07/21/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C10-L6-B4-60	07/21/03	60.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B1-10	07/11/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B1-30	07/11/03	30.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B2-10	07/11/03	10.0	<60	<60	**207**	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C11-L19-B2-15	07/11/03	15.0	<30	<30	**136**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B2-DUP	07/11/03	16.5	<30	<30	**106**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C11-L19-B3-20	07/11/03	20.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B1-10	07/21/03	10.0	<150	<150	**721**	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C12-L3-B1-15	07/21/03	15.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B2-5	07/21/03	5.0	<3.0	<3.0	**5.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B2-10	07/21/03	10.0	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C12-L3-B2-DUP	07/21/03	11.5	<3.0	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C12-L4-B3-5	07/22/03	5.0	<60	<60	**130**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L4-B3-10	07/22/03	10.0	<3.0	<3.0	**9.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B5-25	07/22/03	25.0	**5.0**	<3.0	**5.0**	<0.005	<0.005	<0.005	<0.005	<3.0	ND	ND
C12-L3-B5-30	07/22/03	30.0	**6.0**	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B5-33	07/22/03	33.0	**12**	<3.0	**6.0**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B6-5	07/22/03	5.0	<150	<150	**470**	<0.005	<0.005	<0.005	<0.005	<3.0	--	--
C12-L3-B6-15	07/22/03	15.0	**9.0**	<3.0	<5.0	<0.005	<0.005	<0.005	<0.005	<3.0	--	--

ppm = parts per million
-- = samlpe not analyzed
ND = not detected

Table 3
Vapor Samples Collected from Temporary Sampling Points

Sample Number	Sample Date	Sample Depth	8260 VOCs					8015 TPH
			Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	meta- and para-Xylene µg/L	ortho-Xylene µg/L	Gas Range Organics (GROs) µg/L
C1-L18-SG2-10'	6/16/2003	10	<1	<1	<1	<1	<1	<50
C1-L199-SG1-10'	6/13/2003	10	<1	<1	<1	<1	<1	<50
C1-L199-SG2-10' **	6/13/2003	10	<1	<1	<1	<1	<1	<50
		10	<1	<1	<1	<1	<1	<50
		10	<1	<1	<1	<1	<1	<50
C1-L199-SG3-5'	6/13/2003	5	<1	<1	<1	<1	<1	<50
C1-L199-SG4-5'	6/13/2003	5	<1	<1	<1	<1	<1	<50
C2-L3-SG1-10'	6/6/2003	10	<1	<1	**1.1**	**4.1**	**1**	<50
C2-L3-SG2-10'	6/5/2003	10	<1	**1.8**	**2.2**	**3.9**	**1.2**	<50
C2-L3-SG3-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C2-L3-SG4-10' *	6/5/2003	10	<1	**0.6**	**12**	**56**	**16**	**160**
		10	<1	**0.7**	**12**	**54**	**16**	**140**
		10	<1	**0.6**	**9.1**	**41**	**14**	**110**
C2-L4-SG1-10'	6/6/2003	10	<1	<1	<1	**1.0**	<1	<50
C2-L4-SG2-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C2-L4-SG3-10'	6/5/2003	10	<1	<1	<1	**1.6**	<1	<50
C2-L4-SG3-10' **	6/5/2003	10	<1	<1	<1	**1.5**	<1	<50
C2-L4-SG4-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C3-L14-SG1-10'	6/17/2003	10	<1	<1	<1	<1	<1	<50
C3-L14-SG2-10'	6/17/2003	10	<1	<1	<1	<1	<1	<50
C3-L14-SG2-10'**	6/17/2003	10	<1	<1	<1	<1	<1	<50
C3-L14-SG3-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C3-L14-SG3-10' **	6/18/2003	10	<1	<1	<1	<1	<1	<50
C3-L14-SG4-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C3-L15-SG1-10' *	6/17/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	**240**
			<1	<1	<1	<1	<1	**130**
C3-L15-SG2-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C3-L15-SG3-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C3-L15-SG4-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C3-L16-SG1-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C3-L16-SG2-10'	6/17/2003	10	<1	<1	<1	<1	<1	<50
C3-L16-SG3-10'	6/17/2003	10	<1	<1	<1	<1	<1	<50

Table 3
Vapor Samples Collected from Temporary Sampling Points

			8260 VOCs					8015 TPH
Sample Number	Sample Date	Sample Depth	Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	meta- and para-Xylene µg/L	ortho-Xylene µg/L	Gas Range Organics (GROs) µg/L
C3-L16-SG4-6'	6/17/2003	10	<1	<1	<1	<1	<1	<50
C4-L6-SG1-10'	6/18/2003	10	<1	<1	<1	<1	<1	**73**
C4-L6-SG2-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C4-L6-SG3-10'	6/18/2003	10	<1	<1	<1	<1	<1	**110**
C4-L6-SG4-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C4-L7-SG1-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C4-L7-SG2-10' *	6/18/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	**57**
C4-L7-SG3-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C4-L7-SG4-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C5-L11-SG1-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
C5-L11-SG2-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
C5-L11-SG3-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C5-L11-SG4-10'	6/18/2003	10	<1	<1	<1	<1	<1	<50
C6-L28-SG1-5'	6/16/2003	5	<1	<1	<1	<1	<1	**51**
C6-L28-SG2-6'	6/17/2003	6	<1	<1	<1	<1	<1	<50
C6-L28-SG3-6'	6/17/2003	6	<1	<1	<1	<1	<1	<50
C6-L29-SG1-10'	6/16/2003	10	<1	<1	<1	<1	<1	<50
C6-L29-SG2-6'	6/16/2003	6	<1	<1	<1	<1	<1	<50
C6-L29-SG3-10'	6/16/2003	6	<1	<1	<1	<1	<1	<50
C6-L29-SG4-7'	6/17/2003	7	<1	<1	<1	<1	<1	<50
C6-L29-SG5-8'	6/17/2003	8	<1	<1	<1	<1	<1	<50
C6-L30-SG1-10'	6/17/2003	10	<1	<1	<1	<1	<1	<50
C6-L30-SG2-10'	6/17/2003	10	<1	<1	<1	<1	<1	<50
C6-L30-SG3-10'	6/17/2003	10	<1	<1	<1	<1	<1	<50
C7-L14-SG1-10'	6/16/2003	10	<1	<1	<1	<1	<1	**190**
C7-L14-SG2-10'	6/13/2003	10	<1	<1	<1	<1	<1	<50
C7-L15-SG1-6'	6/13/2003	6	<1	<1	<1	<1	<1	<50
C7-L15-SG2-10'	6/13/2003	10	<1	<1	<1	<1	<1	<50
C7-L15-SG3-10' **	6/13/2003	10	<1	<1	<1	<1	<1	<50

Table 3
Vapor Samples Collected from Temporary Sampling Points

Sample Number	Sample Date	Sample Depth	8260 VOCs Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	meta- and para-Xylene µg/L	ortho-Xylene µg/L	8015 TPH Gas Range Organics (GROs) µg/L
C7-L15-SG3-10'	6/13/2003	10	<1	<1	<1	<1	<1	<50
C7-L15-SG4-10'	6/16/2003	10	<1	<1	<1	<1	<1	**71**
C7-L16-SG1-10'	6/13/2003	10	<1	<1	<1	<1	<1	<50
C7-L16-SG2-6' *	6/13/2003	6	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
C7-L16-SG3-10'	6/13/2003	10	<1	<1	<1	<1	<1	<50
C7-L16-SG4-10'	6/13/2003	10	<1	<1	<1	<1	<1	<50
C7-L17-SG1-10'	6/16/2003	10	<1	<1	<1	<1	<1	<50
C7-L17-SG2-10' *	6/16/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	**170**
			<1	<1	<1	<1	<1	<50
C7-L17-SG3-10'	6/16/2003	10	<1	<1	<1	<1	<1	<50
C7-L17-SG4-10'	6/16/2003	10	<1	<1	<1	<1	<1	<50
C7-L18-SG1-10'	6/16/2003	10	<1	<1	<1	<1	<1	<50
C7-L18-SG1-10' **	6/16/2003	10	<1	<1	<1	<1	<1	<50
C7-L18-SG2-10'	6/16/2003	10	<1	<1	<1	<1	<1	<50
C8-L17-SG1-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L17-SG2-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L17-SG3-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L17-SG4-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L18-SG1-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L18-SG2-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L18-SG3-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L18-SG4-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50

Table 3
Vapor Samples Collected from Temporary Sampling Points

Sample Number	Sample Date	Sample Depth	8260 VOCs					8015 TPH
			Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	meta- and para-Xylene µg/L	ortho-Xylene µg/L	Gas Range Organics (GROs) µg/L
C8-L19-SG1-10' *	6/10/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
C8-L19-SG2-10'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C8-L19-SG3-10'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C8-L19-SG4-10'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C8-L20-SG1-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L20-SG2-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L20-SG2-10' **	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L20-SG3-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L20-SG4-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L22-SG1-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L22-SG2-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L22-SG2-10' **	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L22-SG3-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L22-SG4-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L23-SG1-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L23-SG2-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L23-SG3-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L23-SG4-10'	6/11/2003	10	<1	<1	<1	<1	<1	<50
C8-L24-SG1-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L24-SG2-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L24-SG3-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C8-L24-SG4-10'	6/12/2003	10	<1	<1	<1	<1	<1	<50
C9-L5-SG1-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
C9-L5-SG2-10' *	6/9/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	**1.2**	<1	<50
			<1	<1	<1	<1	<1	<50
C9-L5-SG3-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
C9-L5-SG4-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
C9-L6-SG1-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C9-L6-SG1-10' **	6/6/2003	10	<1	<1	<1	<1	<1	<50
C9-L6-SG2-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50

Table 3
Vapor Samples Collected from Temporary Sampling Points

Sample Number	Sample Date	Sample Depth	8260 VOCs					8015 TPH
			Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	meta- and para-Xylene µg/L	ortho-Xylene µg/L	Gas Range Organics (GROs) µg/L
C9-L6-SG3-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
C9-L7-SG1-10' *	6/6/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
C9-L7-SG2-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C9-L7-SG3-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C9-L7-SG4-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C9-L8-SG1-10'	6/6/2003	10	<1	<1	<1	<1	<1	<50
C9-L8-SG2-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
C9-L8-SG3-10'	6/9/2003	10	<1	<1	<1	<1	<1	<50
C10-L5-SG1-10' *	6/4/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
C10-L5-SG2-10'	6/4/2003	10	<1	<1	<1	<1	<1	<50
C10-L5-SG3-10'	6/4/2003	10	<1	<1	<1	<1	<1	<50
C10-L5-SG4-10'	6/4/2003	10	<1	<1	<1	**1.8**	<1	<50
C10-L6-SG1-10' *	6/4/2003	10	<1	<1	**1.6**	**8.4**	**2.5**	<50
			<1	<1	**1.6**	**7.3**	**2.3**	<50
			<1	<1	**2.0**	**9.7**	**3.0**	<50
C10-L6-SG2-10'	6/4/2003	10	<1	<1	<1	<1	<1	<50
C10-L6-SG3-10'	6/4/2003	10	<1	<1	<1	**2.2**	<1	<50
C10-L6-SG3-10' **	6/4/2003	10	<1	<1	<1	**1.3**	<1	<50
C10-L6-SG4-10'	6/4/2003	10	<1	<1	<1	<1	<1	<50
C10-L7-SG1-10'	6/4/2003	10	<1	<1	<1	<1	<1	<50
C10-L7-SG2-10'	6/4/2003	10	<1	<1	<1	<1	<1	<50
C10-L7-SG3-10'	6/4/2003	10	<1	<1	<1	<1	<1	<50
C10-L7-SG4-10'	6/4/2003	10	<1	<1	<1	**1.1**	<1	<50
C11-L18-SG1 -10'	6/5/2003	10	<1	<1	<1	<1	<1	<50
C11-L18-SG2 -10'	6/5/2003	10	<1	<1	<1	<1	<1	<50

Table 3
Vapor Samples Collected from Temporary Sampling Points

Sample Number	Sample Date	Sample Depth	8260 VOCs Benzene µg/L	Toluene µg/L	Ethylbenzene µg/L	meta- and para-Xylene µg/L	ortho-Xylene µg/L	8015 TPH Gas Range Organics (GROs) µg/L
C11-L19-SG1 -10'	6/5/2003	10	<1	<1	**1.4**	**7.3**	**2.4**	<50
C11-L19-SG2 -10' *	6/5/2003	10	<1	<1	**1.9**	**9.4**	**2.7**	<50
			<1	<1	**2.2**	**10**	**2.9**	<50
			<1	<1	**2.2**	**10**	**2.8**	<50
C11-L19-SG3 -10' *	6/5/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
C11-L19-SG4 -10'	6/5/2003	10	<1	<1	<1	<1	<1	<50
C11-L19-SG5 -10'	6/5/2003	10	<1	<1	<1	<1	<1	<50
C11-L19-SG6 -10'	6/5/2003	10	<1	<1	<1	<1	<1	<50
C11-L19-SG6 -10'**	6/5/2003	10	<1	<1	<1	<1	<1	<50
C12-L3-SG1-8' *	6/10/2003	10	<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
			<1	<1	<1	<1	<1	<50
C12-L3-SG2-7.5'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C12-L3-SG3-5'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C12-L3-SG4-8'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C12-L4-SG1-7.5'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C12-L4-SG2-6'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C12-L4-SG3-8'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C12-L4-SG3-8'	6/10/2003	10	<1	<1	<1	<1	<1	<50
C12-L4-SG4-8'**	6/10/2003	10	<1	<1	<1	<1	<1	<50
Data Summary								
Minimum			0	0.6	1.1	1	1	51
Maximum			0	1.8	12	56	16	240
Depth of Max			na	10	10	10	10	10
Number of Samples			175	175	175	175	175	175
Number of Positive Detections			0	4	12	20	12	12
Frequency of Detection			0%	2%	7%	11%	7%	7%

* Purge volume study
** Duplicate sample
µg/L - micrograms per liter

Table 4
Vapor Samples Collected from Permanent Vapor Monitoring Wells

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs Benzene vppb	Ethylbenzene vppb	m, p-Xylene vppb	o-Xylene vppb	Toluene vppb	Total Xylenes vppb	8015 Gasoline TPH-g vppm	TPH-g µg/L
C1-L199-VW1	8/28/2003	7	<1.47	<1.47	<1.47	<1.47	**2.6**	<0.35	<7.35	<32.487
	9/29/2003		<0.48	<0.35	<0.35	<0.35	**1.2**		<7.8	<27
	11/21/2003		<0.53	<0.39	<0.39	<0.39	**0.61**		<8.6	<30
	12/22/2003		<0.50	<0.65	<0.37	<0.37	<0.37		**8.2**	<29
C2-L3-VW1	8/28/2003	7	<1.86	<1.86	<1.86	<1.86	<1.86	<0.33	**53**	**190**
	9/29/2003		<0.48	<0.35	<0.33	<0.33	**1.9**		<7.3	<26
	11/21/2003		<0.47	<0.35	<0.35	<0.35	**0.61**		<8.6	<27
	12/22/2003		<0.49	<0.36	<0.36	<0.36	**1.2**		<8.1	<28
	12/22/2003		**0.59**	**0.42**	**1.1**	**0.39**	**9.3**		<6.6	<23
C3-L15-VW1	8/28/2003	8	<1.52	**0.63**	**1.2**	**0.58**	**5.2**	**1**	<7.6	<33.592
	9/29/2003		<0.46	**0.38**	**0.71**	**0.34**	**2.5**		<7.5	<26
	11/21/2003		<0.48	<0.35	**0.54**	<0.35	**1**		<7.8	<28
	12/22/2003		<0.50	**0.53**	**2.0**	**0.72**	**3.1**		<8.2	<29
C3-L15-VW1-Dup	8/28/2003	8	<1.47	<1.47	**0.63**	<1.47	**3.3**		<7.35	<32.487
	11/21/2003		<0.51	<0.38	**0.41**	<0.38	**1**		<8.3	<29
C4-L7-VW1	8/28/2003	8	<1.53	**0.71**	**1.2**	**0.88**	**5.2**	**0.79**	<7.65	<33.813
	9/29/2003		<0.47	<0.35	**0.44**	**0.39**	**1.5**		<7.7	<27
	11/21/2003		<0.52	<0.38	<0.38	<0.38	<0.44		<8.5	<30
	12/22/2003		<1.8	<1.4	<1.4	<1.4	<1.6		<7.5	<26
C5-L11-VW1	8/28/2003	7	<1.5	**0.77**	**1.1**	**0.55**	**4.6**	**1.2**	<7.5	<33.15
	9/29/2003		<0.46	**0.43**	**0.78**	**0.42**	**2.1**		<7.5	<26
	11/21/2003		<8.8	<6.5	<6.5	<6.5	<7.5		<7.2	<25
	12/22/2003		<9.6	<7.0	<7.0	<7.0	<8.1		<7.8	<28
C6-L29-VW1	8/28/2003	10	<1.53	<1.53	**0.73**	<1.53	**2.3**	**2.2**	<7.65	<33.813
	9/29/2003		<0.46	**0.61**	**2.2**	<0.34	**1.1**		<7.6	<27
	11/21/2003		<0.93	<0.68	<0.68	<0.68	<0.79		<7.6	<27
	12/22/2003		<11	<7.8	<7.8	<7.8	<9.0		<8.7	<31
C7-L16-VW2	8/28/2003	7	<1.52	<1.52	<1.52	<1.52	**2**	<0.35	<7.6	<33.592
	9/29/2003		<0.47	<0.35	<0.35	<0.35	**0.89**		<7.7	<27
C7-L16-VW1	11/21/2003		<0.50	<0.37	<0.37	<0.37	**0.59**		<8.2	<29
	12/22/2003		<5.1	<3.8	<3.8	<3.8	**7.3**		<8.3	<29

Table 4
Vapor Samples Collected from Permanent Vapor Monitoring Wells

Sample Number	Sample Date	Well Screen Depth (feet bgs)	TO-15 VOCs Benzene vppb	Ethylbenzene vppb	m, p-Xylene vppb	o-Xylene vppb	Toluene vppb	Total Xylenes vppb	8015 Gasoline TPH-g vppm	TPH-g µg/L
C8-L18-VW1	8/28/2003	8	<1.5	**0.44**	**1.3**	**0.71**	**1.7**		<7.5	<33.15
	9/29/2003		<0.46	<0.34	<0.34	<0.34	**3.6**	<0.34	<7.5	<26
	11/21/2003		<0.51	<0.38	<0.38	<0.38	<0.44		<8.4	<30
	12/22/2003		<0.47	<0.35	<0.35	<0.35	**0.81**		<7.7	<27
dup	9/29/2003		<0.46	<0.34	<0.34	<0.34	**0.76**	<0.34	<7.5	<26
C9-L5-VW1	8/28/2003	8	<1.53	<1.53	**0.41**	<1.53	**3**		<7.65	<33.813
	9/29/2003		<0.48	<0.35	**0.54**	<0.35	**1.3**	**0.54**	<7.8	<27
	11/21/2003		<0.49	<0.36	<0.36	<0.36	**0.58**		<8.0	<28
	12/22/2003		<0.55	<0.40	<0.40	<0.40	**1.1**		<8.9	<32
C10-L6-VW1	8/28/2003	7	<1.5	<1.5	**0.61**	<1.5	**2.3**		<7.5	<33.15
	9/29/2003		<0.47	<0.35	<0.35	<0.35	**0.78**	<0.35	<7.7	<27
	11/21/2003		<0.49	<0.36	<0.36	<0.36	**0.48**		<8.1	<28
	12/22/2003		**1.0**	**0.43**	**1.3**	**0.42**	**2.9**		<8.4	30
C11-L19-VW2-Shallow	8/28/2003	10	**15**	**9.3**	**12**	<1.46	**18**		**92**	**320**
	9/29/2003		**13**	**5.8**	**9.7**	**4.2**	**8.7**	**14**	**72**	**250**
	11/21/2003		**23**	**7**	**6.7**	<6.2	**10**		**100**	**370**
	12/22/2003		<3.7	<2.7	<2.7	<2.7	<3.1		**8.7**	**31**
C11-L19-VW2-Deep	8/28/2003	18	<1.49	**2.5**	**4.6**	**2.4**	**13**		**76**	**270**
	9/29/2003		<0.85	**0.63**	**1.4**	**0.83**	**1.7**	**2.2**	<6.9	<24
	11/21/2003		<0.98	<0.72	**1.1**	<0.72	**1**		<8.0	<28
	12/22/2003		<1.2	<0.86	<0.86	<0.86	**2**		<9.5	<33
C12-L3-VW1	8/28/2003	6.5	<1.57	<1.57	<1.57	<1.57	**1.9**		<7.85	<34.697
	9/29/2003		<0.54	<0.40	<0.40	<0.40	**0.98**	<0.4	<8.8	<31
	11/21/2003		<0.44	<0.33	<0.33	<0.33	<0.38		<7.3	<26
	12/22/2003		<0.48	<0.35	<0.35	<0.35	**0.41**		<7.9	<28
Data Sumary										
Minimum			0.59	0.38	0.41	0.34	0.41	0.54	8.2	30
Maximum			23	9.3	12	4.2	18	14	100	370
Depth of Max			10	10	10	10	10	10	10	10
Number of Samples			56	56	56	56	56	14	56	56
Number of Positive Detections			5	15	24	13	45	7	7	7
Frequency of Detection			9%	27%	43%	23%	80%	50%	13%	13%

bgs - below ground surface
µg/L - micrograms per liter
ppbv - parts per billion by volume
ppmv - parts per million by volume

Table 5
Groundwater Samples Collected from Cluster 12

Sample Number	Well Screen Depth (feet bgs)	Sample Date	8260 BTEX Only Benzene µg/L	Ethylbenzene µg/L	Toluene µg/L	Xylenes, total µg/L	8015 TPH-g Only TPH-g µg/L
MW-1	5-20	8/27/2003	<10	20J	<50	36J	448
		9/30/2003	2	7.8	3.5J	13	237
		11/17/2003	6.8	17	6.3	20	439
		12/18/2003	9.1	17	4.6J	18	377
MW-2	5-20	8/27/2003	<1	<5	<5	<5	<50
MW-3	25-35	8/27/2003	<1	1.1J	<5	7.4	80
		9/30/2003	<1	<5	<5	1.3J	65
		11/17/2003	<1	<5	2.3J	4.4J	79
		12/18/2003	<1	11	8.3	42	138
MW-4	5-20	8/27/2003	<1	<5	<5	<5	149
		9/30/2003	<1	2.3J	2.5J	5.5	86
		11/17/2003	<1	2.1J	2.6J	5.3	131
		12/18/2003	1.9	15	10	30	351
MW-5	5-20	8/27/2003	<1	<5	<5	<5	62
		9/30/2003	<1	<5	<5	<5	64
		11/17/2003	<1	<5	<5	<5	73
		12/18/2003	<1	<5	<5	<5	<50
MW-10*	5-20	8/27/2003	<1	<5	<5	<5	146
		9/30/2003	<1	2.1J	2.3J	5	91
MW-4D**		11/17/2003	<1	2.6J	3.1J	6.9	120
MW-DUP***		12/18/2003	7.4	18	4.9J	20	400

* MW-10 is a duplicate sample from MW-4
** MW-4D is a duplicate sample from MW-4
*** MW-DUP is a duplicate sample from MW1
bgs - below ground surface
TPH-g - Total petroleum hydrocarbons as gasoline
µg/L - micrograms per liter
J - Approximate concentration below the laboratory detection limit

APPENDIX B

MODEL RESULTS FOR MIGRATION OF SOIL VAPOR TO INDOOR AIR

1. Johnson and Ettinger Model Input Parameter
2. Output Files for benzene, toluene, ethylbenzene and xylenes

Soil Vapor to Indoor Air
Johnson and Ettinger Vapor Model Input Parameters

Parameters (a)	Input Values	Reference
Soil vapor concentrations (ppmv)	Chemical-specific	Table 3-4
Henry's law constant (unitless) Water diffusion coefficient (cm^2/s) Air diffusion coefficient (cm^2/s) Other chemical parameters: enthalpy of vaporization water solubility boiling point critical temperature	Provided in Johnson & Ettinger VLOOKUP Tables	J&E 2003
Soil Parameters		
Average soil temperature (degrees C)	20	Default for California
Depth below grade to bottom of floor (cm)	15	J&E 1991 for residential
Soil gas sampling depth (cm)	304.8	site specific
SCS soil type (sand)	S	site specific
Thickness of soil stratum (cm)	304.8	site specific
Soil dry bulk density (g/cm^3)	1.61	site specific
Soil total porosity (unitless)	0.397	site specific
Soil water-filled porosity (unitless)	0.078	site specific
Building Parameters		
Height of structure (cm)	488	Two story house for residential
Length of sturcture (cm)	1000	J&E 2003 default
Width of structure (cm)	1000	J&E 2003 default
Floor thickness (cm)	15	J&E 1991 for residential
Floor-wall seam crack width (cm)	0.1	J&E 2003 default
Soil building pressure differential (g/cm^2-sec)	40	J&E 2003 default
Indoor air exchange rate (1/h)	0.66	Murray and Burmaster 1995

Note:
(a) parameters listed are chemical and site specific; values calculated by the model and model defaults are not listed

Acronyms/Abbreviations:
ASTM – American Society for Testing and Materials
C – Celsius
cm – centimeter
cm^2/s – square centimeters per second
cm^3/g – cubic centimeters per gram
g/cm^3 – grams per cubic centimeter
g/cm^2-s – grams per square centimeter per second
SCS – Soil Conservation Service
µg/kg – micrograms per kilogram
1/h – one exchange per hour

References:

J&E 1991. Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Building. Paul C. Johnson and Robert A. Ettinger. Environ. Sci. Technol. 1991, 25, 1445-1452.

J&E 2003. Software Implementation of Johnson and Ettinger Model. Version 3.0. February. United States Environmental Protection Agency.

Murray, D.M. and D.E. Burmaster. 1995. Residential Air Exchange Rate in the United States: Empirical and Estimated Parametric Distribution by Season and Climatic Region. Risk Analysis. Data presented in U.S. EPA Exposure Factors Handbook, Volume III, 1997.

SG-ADV
Version 2.0; 02/03

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432			2.30E-02	Benzene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
			Totals must add up to value of Ls (cell F24)					
15	304.8	20	304.8			s		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
	1.61	0.397	0.078								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	488	0.1	0.66	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	289.8	0.319	ERROR	ERROR	0.074	1.01E-07	0.933	9.42E-08	4,000	7.47E+01	8.95E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.00E+06	4.00E-04	15	8,019	4.39E-03	1.83E-01	1.78E-04	1.24E-02	0.00E+00	0.00E+00	1.24E-02	289.8

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	7.47E+01	0.10	8.33E+01	1.24E-02	4.00E+02	3.56E+109	3.16E-04	2.36E-02	7.8E-06	NA

END

SG-ADV
Version 2.0; 02/03

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
100414			2.72E+00	Ethylbenzene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
15	304.8	20	304.8			s		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
	1.61	0.397	0.078								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	488	0.1	0.66	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	289.8	0.319	ERROR	ERROR	0.074	1.01E-07	0.933	9.42E-08	4,000	1.20E+04	8.95E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.00E+06	4.00E-04	15	10,040	5.89E-03	2.45E-01	1.78E-04	1.06E-02	0.00E+00	0.00E+00	1.06E-02	289.8

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	1.20E+04	0.10	8.33E+01	1.06E-02	4.00E+02	3.47E+128	2.83E-04	3.40E+00	1.1E-06	1.0E+00

END

SG-ADV
Version 2.0; 02/03

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g (μg/m^3)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
108883			4.71E-01	Toluene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
15	304.8	20	304.8			s		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
	1.61	0.397	0.078								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	488	0.1	0.66	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	289.8	0.319	ERROR	ERROR	0.074	1.01E-07	0.933	9.42E-08	4,000	1.80E+03	8.95E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.00E+06	4.00E-04	15	9,045	5.10E-03	2.12E-01	1.78E-04	1.22E-02	0.00E+00	0.00E+00	1.22E-02	289.8

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	1.80E+03	0.10	8.33E+01	1.22E-02	4.00E+02	6.47E+110	3.13E-04	5.65E-01	NA	4.0E-01

END

SG-ADV
Version 2.0; 02/03

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
106423			1.27E+01	p-Xylene

MORE

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
15	304.8	20	304.8			s		

Totals must add up to value of Ls (cell F24)

MORE

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
	1.61	0.397	0.078								

MORE

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	488	0.1	0.66	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	289.8	0.319	ERROR	ERROR	0.074	1.01E-07	0.933	9.42E-08	4,000	5.60E+04	8.95E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.00E+06	4.00E-04	15	10,131	5.71E-03	2.37E-01	1.78E-04	1.08E-02	0.00E+00	0.00E+00	1.08E-02	289.8

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	5.60E+04	0.10	8.33E+01	1.08E-02	4.00E+02	2.32E+125	2.88E-04	1.61E+01	NA	7.0E+00

END

DATA SHEET

SG-ADV
Version 2.0; 02/03

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g (μg/m^3)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
95476			3.62E+00	o-Xylene

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	304.8	20	304.8			s		

Totals must add up to value of Ls (cell F24)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
	1.61	0.397	0.078								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	488	0.1	0.66	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. (µg/m^3)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	289.8	0.319	ERROR	ERROR	0.074	1.01E-07	0.933	9.42E-08	4,000	1.60E+04	8.95E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.00E+06	4.00E-04	15	10,291	3.85E-03	1.60E-01	1.78E-04	1.22E-02	0.00E+00	0.00E+00	1.22E-02	289.8

Convection path length, L_p (cm)	Source vapor conc., C_{source} (µg/m^3)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, exp(Pe^f) (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ (µg/m^3)	Unit risk factor, URF (µg/m^3)$^{-1}$	Reference conc., RfC (mg/m^3)
15	1.60E+04	0.10	8.33E+01	1.22E-02	4.00E+02	6.47E+110	3.13E-04	5.01E+00	NA	7.0E+00

END

APPENDIX C

EQUATIONS USED TO CALCULATE THE RISK

1. California Preliminary Endangerment Assessment (PEA) Guidance: Exposure and Risk Equations
2. California Preliminary Endangerment Assessment (PEA) Guidance: Derivation of Equations

California Preliminary Endangement Assessment (PEA) Guidance Document
Exposure and Risk Equations

These equations from the California Preliminary Endangerment Assessment Guidance were used to calculate concentrations in outdoor air, noncancer hazard fo children and cancer risk for children and adult residents. These equations are presented in the PEA guidance in a reduced format that does not show all the exposure assumptions listed on Table 3-6 of the risk assessment. Expanded versions of these equations are included in the next portion of this Appendix.

Equation 1. Volatile Organic Chemical Concentrations in Outdoor Air

Ca = Ei / 99

where

Ca = ambient air concentration, milligrams per cubic meter (mg/m^3)

Ei = total emission reate for compound i, milligrams per second (mg/s), from Equation 2.

Equation 2. Total Emission Rate for Volatile Organic Chemicals

$$E_i = \frac{1.6x10^5 \text{ x } D_i \text{ x } \frac{H_c}{K_d} \text{ x } C_i}{\sqrt{D_i \text{ x } \frac{0.023}{0.284 + 0.046x \frac{K_d}{H_c}}}}$$

where

Ei = average emission rate of compound i, over the residential lot during the exposure interval, mg/s

Di = diffusivity in air for compound i, square centimeters per second (cm^2/s)

Hc = Henry's Law constant, atmosphere-cubic meter per mole ($atm\text{-}m^3/mol$)

Kd = soil-water partition coefficient, cubic centimeters per gram (cm^3/g)

Ci = bulk soil concentration of contaminant i, as follows: chemical concentration in soil, milligrams per kilogram (mg/kg), x 10^{-6} kilograms per milligram (kg/mg)

Equation 3. Particulate Concentrations in Outdoor Air

Ca = Cs x ($5x10^{-8}$ kg/m^3)

where

Ca = ambient air concentration, milligrams per cubic meter (mg/m^3)

Cs = chemical concentration in soil, milligrams per kilogram (mg/kg)

Equation 4. Noncancer Hazard for Child Resident, Soil Exposure Pathway

Hazard (soil) = ((Cs/RfDo) x ($1.28x10^{-5}$)) + ((Cs/RfDo) x ($1.28x10^{-4}$) x ABS)

where

Cs = chemical concentration in soil, milligrams per kilogram (mg/kg)

RfDo = oral reference dose, mg/kg-day

ABS = absorption fraction, unitless

Equation 5. Noncancer Hazard for Child Resident, Air Exposure Pathway

Hazard (air) = (Ca/RfDi) x 0.639
where
Ca = ambient air concentration, milligrams per cubic meter (mg/m^3)
RfDi = inhalation reference dose, mg/kg-day

Equation 6. Cancer Risk for Resident, Soil Exposure Pathway

Risk (soil) = ((Cs x SFo) x (1.57×10^{-6})) + ((Cs x SFo) x (1.87×10^{-5}) x ABS)
where
Cs = chemical concentration in soil, milligrams per kilogram (mg/kg)
SFo = oral cancer slope factor, $(mg/kg\text{-}day)^{-1}$
ABS = absorption fraction, unitless

Equation 7. Cancer Risk for Resident, Air Exposure Pathway

Risk (air) = (Ca x SFi) x 0.149
where
Ca = ambient air concentration, milligrams per cubic meter (mg/m^3)
SFi = inhalation cancer slope factor, $(mg/kg\text{-}day)^{-1}$

California Preliminary Endangement Assessment (PEA) Guidance Document
Derivation of Risk Equations

This section presents the expanded PEA equations used to calculate the risks so that each of the exposure assumptions shown in Table 3-6 of the risk assessment can be seen. The reduce version of the equations is presented on to the previous table in this Appendix.

Noncancer Hazard for Child Resident, Soil Exposure Pathway

Original Equation:

Hazard (soil) = (1/RfDo) x (Cs x IRs x EF x ED x 10-6 kg/mg)/(BW x AT)
+ (1/RfDo) x (CS x SA x AF x ABS x EF x ED x 10-6 kg/mg)/(BW x AT)

where

Cs = chemical concentration in soil, mg/kg, chemical specific
RfDo = oral reference dose, mg/kg-day, chemical specific
IRs = incidental soil ingestion rate, 200 mg/day
EF = exposure frequency, 350 days/year
ED = exposure duration, 6 years
BW = body weight, 15 kg
AT = averaging time, 2190 days
SA = skin surface area exposed, 2000 cm^2
AF = soil to skin adherence factor, 1 mg/cm^2
ABS = absorption fraction of chemical from soil, chemical specific

Reduced Equation:

Hazard (soil) = ((Cs/RfDo) x ($1.28x10^{-5}$)) + ((Cs/RfDo) x ($1.28x10^{-4}$) x ABS)

where

Cs = chemical concentration in soil, mg/kg, chemical specific
RfDo = oral reference dose, mg/kg-day, chemical specific
ABS = absorption fraction, dimensionless (0.10)

Noncancer Hazard for Child Resident, Air Exposure Pathway

Original Equation:

Hazard (air) = (1/RfDi) x (Ca x IR x EF x ED)/(BW x AT)

where

Ca = ambient air concentration, mg/m^3, chemical specific
RfDi = inhalation reference dose, mg/kg-day, chemical specific
IR = inhalation rate, 10 m^3/day
EF = exposure frequency, 350 days/year
ED = exposure duration, 6 years
BW = body weight, 15 kg
AT = averaging time, 2190 days

Reduced Equation:

Hazard (air) = (Ca/RfDi) x 0.639

where

Ca = ambient air concentration, mg/m^3, chemical specific
RfDi = inhalation reference dose, mg/kg-day, chemical specific

California Preliminary Endangement Assessment (PEA) Guidance Document
Derivation of Risk Equations

Cancer Risk for Resident, Soil Exposure Pathway

Original Equation:

Risk (soil) = SFo x (Cs x IRs,adult x EF x EDadult x 10-6 kg/mg)/(BWadult x AT)
+ SFo x (Cs x IRs,child x EF x EDchild x 10-6 kg/mg)/(BWchild x AT)
+ SFo x (CS x SAadult x AF x ABS x EFadult x EDadult x 10-6 kg/mg)/(BWadult x AT)
+ SFo x (CS x SAchild x AF x ABS x EFchild x EDchild x 10-6 kg/mg)/(BWchild x AT)

where

SFo	=	oral cancer slope factor, $(mg/kg\text{-}day)^{-1}$, chemical specific
Cs	=	chemical concentration in soil, mg/kg, chemical specific
IR	=	incidental soil ingestion rate, 200 mg/day for children and 100 mg/day for adults
EF	=	exposure frequency for soil ingestion, 350 days/year exposure frequency for dermal contact, 350 days/year for children and 100 days/year for adults
ED	=	exposure duration, 6 years for children and 24 years for adults
BW	=	body weight, 15 kg for children and 70 kg for adults
AT	=	averaging time, 25550 days
SA	=	skin surface area exposed, 2000 cm^2 for chilren and 5800 cm^2 for adults
AF	=	soil to skin adherence factor, 1 mg/cm^2
ABS	=	absorption fraction of chemical from soil, chemical specific

Reduced Equation:

Risk (soil) = ((Cs x SFo) x $(1.57\text{x}10^{-6})$) + ((Cs x SFo) x $(1.87\text{x}10^{-5})$ x ABS)

where

Cs	=	chemical concentration in soil, mg/kg, chemical specific
SFo	=	oral cancer slope factor, $(mg/kg\text{-}day)^{-1}$, chemical specific
ABS	=	absorption fraction of chemical from soil, chemical specific

Cancer Risk for Resident, Air Exposure Pathway

Original Equation:

Risk (air) = SFi x (Ca x IRadult x EF x EDadult)/(BWadult x AT)
+ SFi x (Ca x IRchild x EF x EDchild)/(BWchild x AT)

SFi	=	inhalation cancer slope factor, $(mg/kg\text{-}day)^{-1}$, chemical specific
Ca	=	ambient air concentration, milligrams per cubic meter (mg/m^3)
IR	=	inhalation rate, 10 m^3/day for children and 20 m^3/day for adults
EF	=	exposure frequency, 350 days/year
ED	=	exposure duration, 6 years for children and 24 years for adults
BW	=	body weight, 15 kg for children and 70 kg for adults
AT	=	averaging time, 25550 days

Reduced Equation:

Risk (air) = (Ca x SFi) x 0.149

where

Ca	=	ambient air concentration, milligrams per cubic meter (mg/m^3)
SFi	=	inhalation cancer slope factor, $(mg/kg\text{-}day)^{-1}$, chemical specific

APPENDIX D

TOXICOLOGICAL PROFILES OF CHEMICALS

1. Toxicological Profiles for benzene, toluene, ethylbenzene and xylenes

ATSDR
AGENCY FOR TOXIC SUBSTANCES
AND DISEASE REGISTRY

BENZENE
CAS # 71-43-2

Agency for Toxic Substances and Disease Registry ToxFAQs September 1997

This fact sheet answers the most frequently asked health questions (FAQs) about benzene. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Benzene is a widely used chemical formed from both natural processes and human activities. Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. Benzene has been found in at least 813 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is benzene?
(Pronounced bĕn′zēn′)

Benzene is a colorless liquid with a sweet odor. It evaporates into the air very quickly and dissolves slightly in water. It is highly flammable and is formed from both natural processes and human activities.

Benzene is widely used in the United States; it ranks in the top 20 chemicals for production volume. Some industries use benzene to make other chemicals which are used to make plastics, resins, and nylon and synthetic fibers. Benzene is also used to make some types of rubbers, lubricants, dyes, detergents, drugs, and pesticides. Natural sources of benzene include volcanoes and forest fires. Benzene is also a natural part of crude oil, gasoline, and cigarette smoke.

What happens to benzene when it enters the environment?

- ❑ Industrial processes are the main source of benzene in the environment.
- ❑ Benzene can pass into the air from water and soil.
- ❑ It reacts with other chemicals in the air and breaks down within a few days.
- ❑ Benzene in the air can attach to rain or snow and be carried back down to the ground.
- ❑ It breaks down more slowly in water and soil, and can pass through the soil into underground water.
- ❑ Benzene does not build up in plants or animals.

How might I be exposed to benzene?

- ❑ Outdoor air contains low levels of benzene from tobacco smoke, automobile service stations, exhaust from motor vehicles, and industrial emissions.
- ❑ Indoor air generally contains higher levels of benzene from products that contain it such as glues, paints, furniture wax, and detergents.
- ❑ Air around hazardous waste sites or gas stations will contain higher levels of benzene.
- ❑ Leakage from underground storage tanks or from hazardous waste sites containing benzene can result in benzene contamination of well water.
- ❑ People working in industries that make or use benzene may be exposed to the highest levels of it.
- ❑ A major source of benzene exposures is tobacco smoke.

How can benzene affect my health?

Breathing very high levels of benzene can result in death, while high levels can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, and death.

The major effect of benzene from long-term (365 days or longer) exposure is on the blood. Benzene causes harmful effects on the bone marrow and can cause a decrease in red blood cells leading to anemia. It can also cause excessive bleeding and can affect the immune system, increasing the chance for infection.

Some women who breathed high levels of benzene for many months had irregular menstrual periods and a decrease in the size of their ovaries. It is not known whether benzene exposure affects the developing fetus in pregnant women or fertility in men.

Animal studies have shown low birth weights, delayed bone formation, and bone marrow damage when pregnant animals breathed benzene.

How likely is benzene to cause cancer?

The Department of Health and Human Services (DHHS) has determined that benzene is a known human carcinogen. Long-term exposure to high levels of benzene in the air can cause leukemia, cancer of the blood-forming organs.

Is there a medical test to show whether I've been exposed to benzene?

Several tests can show if you have been exposed to benzene. There is test for measuring benzene in the breath; this test must be done shortly after exposure. Benzene can also be measured in the blood, however, since benzene disappears rapidly from the blood, measurements are accurate only for recent exposures.

In the body, benzene is converted to products called metabolites. Certain metabolites can be measured in the urine. However, this test must be done shortly after exposure and is not a reliable indicator of how much benzene you have been exposed to, since the metabolites may be present in urine from other sources.

Has the federal government made recommendations to protect human health?

The EPA has set the maximum permissible level of benzene in drinking water at 0.005 milligrams per liter (0.005 mgL). The EPA requires that spills or accidental releases into the environment of 10 pounds or more of benzene be reported to the EPA.

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit of 1 part of benzene per million parts of air (1 ppm) in the workplace during an 8-hour workday, 40-hour workweek.

Glossary

Anemia: A decreased ability of the blood to transport oxygen.

Carcinogen: A substance with the ability to cause cancer.

CAS: Chemical Abstracts Service.

Chromosomes: Parts of the cells responsible for the development of hereditary characteristics.

Metabolites: Breakdown products of chemicals.

Milligram (mg): One thousandth of a gram.

Pesticide: A substance that kills pests.

References

This ToxFAQs information is taken from the 1997 Toxicological Profile for Benzene (update) produced by the Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Public Health Service in Atlanta, GA.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop E-29, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 404-498-0093. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

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AGENCY FOR TOXIC SUBSTANCES
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ETHYLBENZENE
CAS # 100-41-4

Agency for Toxic Substances and Disease Registry ToxFAQs **June 1999**

This fact sheet answers the most frequently asked health questions (FAQs) about ethylbenzene. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Ethylbenzene is a colorless liquid found in a number of products including gasoline and paints. Breathing very high levels can cause dizziness and throat and eye irritation. Ethylbenzene has been found in at least 731 of the 1,467 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is ethylbenzene?
(Pronounced ĕth′ əl bĕn′ zēn′)

Ethylbenzene is a colorless, flammable liquid that smells like gasoline. It is found in natural products such as coal tar and petroleum and is also found in manufactured products such as inks, insecticides, and paints.

Ethylbenzene is used primarily to make another chemical, styrene. Other uses include as a solvent, in fuels, and to make other chemicals.

What happens to ethylbenzene when it enters the environment?

- Ethylbenzene moves easily into the air from water and soil.
- It takes about 3 days for ethylbenzene to be broken down in air into other chemicals.
- Ethylbenzene may be released to water from industrial discharges or leaking underground storage tanks.
- In surface water, ethylbenzene breaks down by reacting with other chemicals found naturally in water.
- In soil, it is broken down by soil bacteria.

How might I be exposed to ethylbenzene?

- Breathing air containing ethylbenzene, particularly in areas near factories or highways.
- Drinking contaminated tap water.
- Working in an industry where ethylbenzene is used or made.
- Using products containing it, such as gasoline, carpet glues, varnishes, and paints.

How can ethylbenzene affect my health?

Limited information is available on the effects of ethylbenzene on people's health. The available information shows dizziness, throat and eye irritation, tightening of the chest, and a burning sensation in the eyes of people exposed to high levels of ethylbenzene in air.

Animals studies have shown effects on the nervous system, liver, kidneys, and eyes from breathing ethylbenzene in air.

How likely is ethylbenzene to cause cancer?

The EPA has determined that ethylbenzene is not classifiable as to human carcinogenicity.

No studies in people have shown that ethylbenzene exposure can result in cancer. Two available animal studies suggest that ethylbenzene may cause tumors.

How can ethylbenzene affect children?

Children may be exposed to ethylbenzene through inhalation of consumer products, including gasoline, paints, inks, pesticides, and carpet glue. We do not know whether children are more sensitive to the effects of ethylbenzene than adults.

It is not known whether ethylbenzene can affect the development of the human fetus. Animal studies have shown that when pregnant animals were exposed to ethylbenzene in air, their babies had an increased number of birth defects.

How can families reduce the risk of exposure to ethylbenzene?

Exposure to ethylbenzene vapors from household products and newly installed carpeting can be minimized by using adequate ventilation.

Household chemicals should be stored out of reach of children to prevent accidental poisoning. Always store household chemicals in their original containers; never store them in containers children would find attractive to eat or drink from, such as old soda bottles. Gasoline should be stored in a gasoline can with a locked cap.

Sometimes older children sniff household chemicals, including ethylbenzene, in an attempt to get high. Talk with your children about the dangers of sniffing chemicals.

Is there a medical test to show whether I've been exposed to ethylbenzene?

Ethylbenzene is found in the blood, urine, breath, and some body tissues of exposed people. The most common way to test for ethylbenzene is in the urine. This test measures substances formed by the breakdown of ethylbenzene. This test needs to be done within a few hours after exposure occurs, because the substances leave the body very quickly.

These tests can show you were exposed to ethylbenzene, but cannot predict the kind of health effects that might occur.

Has the federal government made recommendations to protect human health?

The EPA has set a maximum contaminant level of 0.7 milligrams of ethylbenzene per liter of drinking water (0.7 mg/L).

The EPA requires that spills or accidental releases into the environment of 1,000 pounds or more of ethylbenzene be reported to the EPA.

The Occupational Safety and Health Administration (OSHA) has set an occupational exposure limit of 100 parts of ethylbenzene per million parts of air (100 ppm) for an 8-hour workday, 40-hour workweek.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. Toxicological profile for ethylbenzene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop E-29, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 404-498-0093. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

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AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

TOLUENE
CAS # 108-88-3

Division of Toxicology ToxFAQs™ **February 2001**

This fact sheet answers the most frequently asked health questions (FAQs) about toluene. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Exposure to toluene occurs from breathing contaminated workplace air, in automobile exhaust, some consumer products paints, paint thinners, fingernail polish, lacquers, and adhesives. Toluene affects the nervous system. Toluene has been found at 959 of the 1,591 National Priority List sites identified by the Environmental Protection Agency

What is toluene?

Toluene is a clear, colorless liquid with a distinctive smell. Toluene occurs naturally in crude oil and in the tolu tree. It is also produced in the process of making gasoline and other fuels from crude oil and making coke from coal.

Toluene is used in making paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber and in some printing and leather tanning processes.

What happens to toluene when it enters the environment?

❑ Toluene enters the environment when you use materials that contain it. It can also enter surface water and groundwater from spills of solvents and petrolieum products as well as from leasking underground storage tanks at gasoline stations and other facilities.

❑ When toluene-containing products are placed in landfills or waste disposal sites, the toluene can enter the soil or water near the waste site.

❑ Toluene does not usually stay in the environment long.

❑ Toluene does not concentrate or buildup to high levels in animals.

How might I be exposed to toluene?

❑ Breathing contaminated workplace air or automobile exhaust.

❑ Working with gasoline, kerosene, heating oil, paints, and lacquers.

❑ Drinking contaminated well-water.

❑ Living near uncontrolled hazardous waste sites containing toluene products.

How can toluene affect my health?

Toluene may affect the nervous system. Low to moderate levles can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, loss of appetite, and hearing and color vision loss. These symptoms usually disappear when exposure is stopped.

Inhaling High levels of toluene in a short time can make you feel light-headed, dizzy, or sleepy. It can also cause unconsciousness, and even death.

High levels of toluene may affect your kidneys.

How likely is toluene to cause cancer?

Studies in humans and animals generally indicate that toluene does not cause cancer.

The EPA has determined that the carcinogenicity of toluene can not be classified.

How can toluene affect children?

It is likely that health effects seen in children exposed to toluene will be similar to the effects seen in adults.
Some studies in animals suggest that babies may be more sensitive than adults.

Breathing very high levels of toluene during pregnancy can result in children with birth defects and retard mental abilities, and growth. We do not know if toluene harms the unborn child if the mother is exposed to low levels of toluene during pregnancy.

How can families reduce the risk of exposure to toluene?

❑ Use toluene-containing products in well-ventilated areas.

❑ When not in use, toluene-containing products should be tightly covered to prevent evaporation into the air.

Is there a medical test to show whether I've been exposed to toluene?

There are tests to measure the level of toluene or its breakdown products in exhaled air, urine, and blood. To determine if you have been exposed to toluene, your urine or blood must be checked within 12 hours of exposure. Several other chemicals are also changed into the same breakdown products as toluene, so some of these tests are not specific for toluene.

Has the federal government made recommendations to protect human health?

EPA has set a limit of 1 milligram per liter of drinking water (1 mg/L).

Discharges, releases, or spills of more than 1,000 pounds of toluene must be reported to the National Response Center.

The Occupational Safety and Health Administration has set a limit of 200 parts toluene per million of workplace air (200 ppm).

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological Profile for Toluene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop E-29, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 404-498-0093. ToxFAQs™ Internet address is http://www.atsdr.cdc.gov/toxfaq.html. ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

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AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

XYLENE
CAS # 1330-20-7

Agency for Toxic Substances and Disease Registry ToxFAQs September 1996

This fact sheet answers the most frequently asked health questions (FAQs) about xylene. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

SUMMARY: Exposure to xylene occurs in the workplace and when you use paint, gasoline, paint thinners and other products that contain it. People who breathe high levels may have dizziness, confusion, and a change in their sense of balance. This substance has been found in at least 658 of the 1,430 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What is xylene?

(Pronounced zī′lēn)

Xylene is a colorless, sweet-smelling liquid that catches on fire easily. It occurs naturally in petroleum and coal tar and is formed during forest fires. You can smell xylene in air at 0.08–3.7 parts of xylene per million parts of air (ppm) and begin to taste it in water at 0.53–1.8 ppm.

Chemical industries produce xylene from petroleum. It's one of the top 30 chemicals produced in the United States in terms of volume.

Xylene is used as a solvent and in the printing, rubber, and leather industries. It is also used as a cleaning agent, a thinner for paint, and in paints and varnishes. It is found in small amounts in airplane fuel and gasoline.

What happens to xylene when it enters the environment?

- Xylene has been found in waste sites and landfills when discarded as used solvent, or in varnish, paint, or paint thinners.
- It evaporates quickly from the soil and surface water into the air.
- In the air, it is broken down by sunlight into other less harmful chemicals.
- It is broken down by microorganisms in soil and water.
- Only a small amount of it builds up in fish, shellfish, plants, and animals living in xylene-contaminated water.

How might I be exposed to xylene?

- Breathing xylene in workplace air or in automobile exhaust.
- Breathing contaminated air.
- Touching gasoline, paint, paint removers, varnish, shellac, and rust preventatives that contain it.
- Breathing cigarette smoke that has small amounts of xylene in it.
- Drinking contaminated water or breathing air near waste sites and landfills that contain xylene.
- The amount of xylene in food is likely to be low.

How can xylene affect my health?

Xylene affects the brain. High levels from exposure for short periods (14 days or less) or long periods (more than 1 year) can cause headaches, lack of muscle coordination, dizziness, confusion, and changes in one's sense of balance. Exposure of people to high levels of xylene for short periods can also cause irritation of the skin, eyes, nose, and throat; difficulty in breathing; problems with the lungs; delayed reaction time; memory difficulties; stomach discomfort; and possibly changes in the liver and kidneys. It can cause unconsciousness and even death at very high levels.

Studies of unborn animals indicate that high concentrations of xylene may cause increased numbers of deaths, and delayed growth and development. In many instances, these same concentrations also cause damage to the mothers. We do not know if xylene harms the unborn child if the mother is exposed to low levels of xylene during pregnancy.

How likely is xylene to cause cancer?

The International Agency for Research on Cancer (IARC) has determined that xylene is not classifiable as to its carcinogenicity in humans.

Human and animal studies have not shown xylene to be carcinogenic, but these studies are not conclusive and do not provide enough information to conclude that xylene does not cause cancer.

Is there a medical test to show whether I've been exposed to xylene?

Laboratory tests can detect xylene or its breakdown products in exhaled air, blood, or urine. There is a high degree of agreement between the levels of exposure to xylene and the levels of xylene breakdown products in the urine. However, a urine sample must be provided very soon after exposure ends because xylene quickly leaves the body. These tests are not routinely available at your doctor's office.

Has the federal government made recommendations to protect human health?

The EPA has set a limit of 10 ppm of xylene in drinking water.

The EPA requires that spills or accidental releases of xylenes into the environment of 1,000 pounds or more must be reported.

The Occupational Safety and Health Administration (OSHA) has set a maximum level of 100 ppm xylene in workplace air for an 8-hour workday, 40-hour workweek.

The National Institute for Occupational Safety and Health (NIOSH) and the American Conference of Governmental Industrial Hygienists (ACGIH) also recommend exposure limits of 100 ppm in workplace air.

NIOSH has recommended that 900 ppm of xylene be considered immediately dangerous to life or health. This is the exposure level of a chemical that is likely to cause permanent health problems or death.

Glossary

Evaporate: To change from a liquid into a vapor or a gas.

Carcinogenic: Having the ability to cause cancer.

CAS: Chemical Abstracts Service.

ppm: Parts per million.

Solvent: A liquid that can dissolve other substances.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. Toxicological profile for xylenes (update). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop E-29, Atlanta, GA 30333. Phone:1-888-422-8737, FAX: 404-498-0093. ToxFAQs Internet address via WWW is http://www.atsdr.cdc.gov/toxfaq.html ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.